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VOL III NO 1

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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JULY 1918

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

"Whenever we have had a bearing at some vital point and wanted to forget about the bearing once it was installed, we have never considered anything except Non-Gran."

THE author of the letter from which this statement is taken is one of the few automotive engineers whose opinion is sought by Government authorities.

HIGH SPEED
NON-GRAN
BEARING BRONZE

AMERICAN BRONZE CORPORATION

Berwyn Pennsylvania

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. III July, 1918 No. 1

The SEMI-ANNUAL MEETING OF THE SOCIETY

THE 1918 Summer Meeting, held June 17 and 18 at Triangle Park, Dayton, was undoubtedly the most notable, as regards both variety of attraction and breadth of interest, of any ever held by the Society. The educational purpose of the meeting was carried out most thoroughly by the exhibition and operation of aircraft, motor trucks and tractors, and by the presentation of a number of professional papers.

The real message of the meeting was expressed by Mr. Kettering when he urged the members of the Society to study new developments and become interested in the fundamentals of the automotive industry. What is required, he said, is the cooperative contribution of ideas; one man's ideas may not amount to much, but by adding every little bit together wonderful results can be achieved.

While the main Society meeting was scheduled for only two days, in all five days were devoted to S. A. E. affairs. On Saturday, June 15, a number of the Divisions of the Standards Committee met at the Engineers Club. The Standards Committee meeting took place on the 16th, also at the Engineers Club. The Society sessions were held at Triangle Park on the 17th and 18th, and on the 19th many of the members visited the local factories at Dayton. On Wednesday morning a special train carried the members to Moraine City, just outside Dayton, where they were shown through the plant of the Dayton-Wright Airplane Company.

The city of Dayton gave a royal welcome to the visiting members and guests of the Society. The Dayton S. A. E. Committee worked untiringly for the convenience of the visitors, an efficient transportation committee saw that practically continuous service was afforded in getting to Triangle Park, to the Community Country Club and St. Marys College, where a number of the members stopped. Mayor J. M. Switzer of Dayton, in a statement of welcome, said, "Our citizens are concerned that your stay may be pleasant and profitable; so take whatever you may find and use it to the utmost for your convenience, comfort and welfare in every way; and then come again sometime, and good luck for a successful meeting." The spirit embodied in this statement was displayed by all the citizens of Dayton, particularly by the large number of committee workers connected with the Dayton automotive factories and with the Dayton Bicycle Club. That the meeting was "the biggest, best enjoyed, most serious and most successful ever conducted by the Society," was due in great part to their whole-hearted efforts. (The description is quoted from "The Daily S. A. E," the little convention daily that was one of the bright spots of the meeting.)

Proceedings at the Business Session

The business session was called to order shortly after ten Monday morning by President Kettering, who in his opening remarks called attention to the fact that all exhibits and demonstrations were of an educational nature, of devices directly concerned in Government work and in winning the war. He said also that the papers to be presented would deal with the fundamentals of Society activities.

The treasurer of the Society, C. B. Whittelsey, then presented a report showing that the financial affairs of the Society are in a healthy condition, there being investments amounting to $48,286.12, of which $24,000 is in Liberty Bonds. The report was accepted.

Membership Increase Activities

The following report, which was approved, was submitted for the Membership Committee by Field Secretary R. E. Plimpton:

"The work of the present committee covers the first five months of this year, or from the middle of January to the middle of June. During that period 358 applications have been presented to the Council of the Society and have received its approval. This figure can be compared with the 452 applications approved by the Council during the same five months of 1917.

"The applications approved thus far in 1918 consist of the following:

Members	152
Assocates	117
Juniors	59
Affiliates	2
Affiliate Member Representatives	5
Student Enrollments	23
Total	358

"The total membership of the Society is now (June 17) 3547, an increase of about 14 per cent since Jan. 30, 1918, when the total membership was 3196. During the corresponding period in 1917 the membership was increased nearly 25 per cent. As previously indicated, the number of applications approved during the first five months of 1917 is about 25 per cent larger than during the same period this year. It is unfortunate that the fine record made last year, when a large number of members

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could spare time to get new members and when new members came in as a result of the amalgamation of the various automotive engineering organizations, could not have been equalled this year.

"The Membership Committee believes that the present and future of automotive engineering are such as to justify an immediate and large increase in membership. The Society as an organization is doing its patriotic duty. Individual members are also doing their duty to the Nation in the finest way. The Committee wants them to realize that the strengthening of the Society is equally a part of their patriotic duty. Let every member take every opportunity to urge eligible men to join the S. A. E.

"The Committee has already taken various steps to secure new members. Invitations to join the Society have been sent out to several hundred persons whose names have been suggested by members of the Society. A number of members in the different automotive centers are doing good work in helping the committee; the support of all S. A. E. members is urgently requested in order to build up the Society to the fullest extent."

Cablegram from Overseas

President Kettering read the following cablegram received from S. A. E. members on the other side:

"S. A. E., Dayton, Ohio:

"Demonstration thus far of American fighting genius expressed in standardized automotive apparatus causing the Kaiser sleepless nights. Keep coming.

"Bradley, Chryst, Franks, Gloetzner, Homan, Jennings, Johnson, Norton, Slade, Utz, Wetherill."

Mr. Kettering appointed F. G. Hughes as chairman of the Committee to send a reply to the cablegram. The following reply was composed by Mr. Hughes, assisted by Messrs. Clarkson and Ehrman, and sent:

"Major S. P. Wetherill, Jr., A. E. F., France:

"S. A. E. war convention Dayton over here completing preparations for standardizing the Kaiser's long sleep. Greetings to our men over there.

Society of Automotive Engineers."

Report of Publication Committee

The following report was presented by E. R. Greer of the Publication Committee of the Society:

"During the past five months, or since the present Publication Committee was appointed, Part II of the 1917 TRANSACTIONS of the Society has been prepared for publication, printed and sent to the members. Part I of the 1918 TRANSACTIONS is now on the way, and the members of the Committee are considering material available for inclusion therein. It is expected that this volume will be issued to the members the latter part of the summer.

"The publications of the Society are one of the very tangible benefits of membership. Every effort should be made, therefore, to keep up the standard. Each issue of the TRANSACTIONS should be a summary of the automotive engineering development during a six months' period, so that the members receive a continually growing working library as a part of their connection with the Society.

"But in order to make the TRANSACTIONS really worthy, each member must do his part in preparing papers for the Society and Section meetings and in entering into the discussion of such papers.

"The reports of the Standards Committee are an important part of each issue of the TRANSACTIONS, and the Committee believes that they should be made even more complete than is the case at present. These reports should give more information regarding the engineering practices leading up to specific recommendations in order that the standardization activities of the Society may be so recorded as to be of the maximum value for the future.

"The S. A. E. Handbook is, of course, a medium through which the recommendations of the Standards Committee are presented in abbreviated form to the members. The reasons for making such recommendations should be given in the complete report in the TRANSACTIONS. When new developments affect any standards, a supplementary report should be made revising previous actions and giving the reason for so doing. These later reports should in turn be condensed for use in the S. A. E. Handbook.

"The monthly periodical of the Society, THE JOURNAL, which has now been issued a year in its present form, seems to have met with the general approval of the members. This periodical is really the most direct point of contact by which the officers of the Society, the Sections, and the individual members are brought together each month.

"The technical papers, news of Society, Section and member activities given in THE JOURNAL, make it an essential factor in carrying on the Society work. The papers in THE JOURNAL, considered by the Publication Committee of permanent engineering value, are reprinted in the TRANSACTIONS, but much other matter of interest appears in THE JOURNAL alone.

"The advertising section of THE JOURNAL has increased in volume since the present form was adopted. This feature is conducted with the view to making it a real technical educational factor, and it is believed that such a result is being accomplished."

The report of the Publication Committee being accepted, President Kettering said that the members had one of the "livest" publications in the country in THE JOURNAL, and that they should both read it and write for it. He also said that advertising in THE JOURNAL was worth while and was to be recommended.

Nominating Committee Election

The next business was the election of three members at large of the Nominating Committee of the Society. General Manager Clarkson explained that the Committee, which has the duty of nominating Society officers for 1919, was composed of the following members, already elected by the Sections:

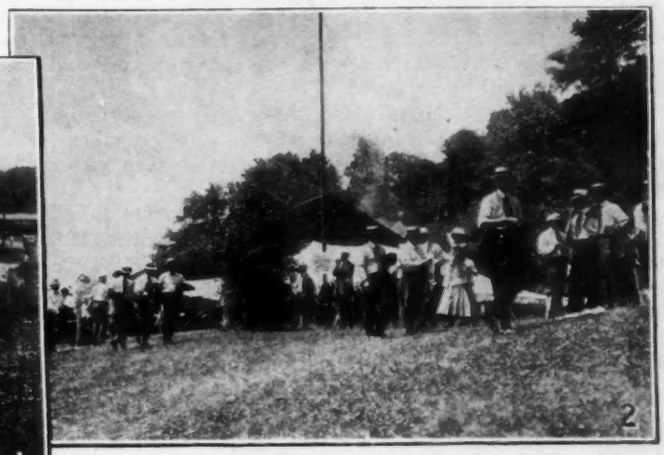
Buffalo Section	H. R. Corse
Cleveland Section	R. E. Clingan
Detroit Section	R. E. Wells
Indiana Section	W. S. Reed
Mid-West Section	F. E. Place
Metropolitan Section	C. F. Scott
Minneapolis Section	H. C. Buffington
Pennsylvania Section	W. H. Palmer, Jr.

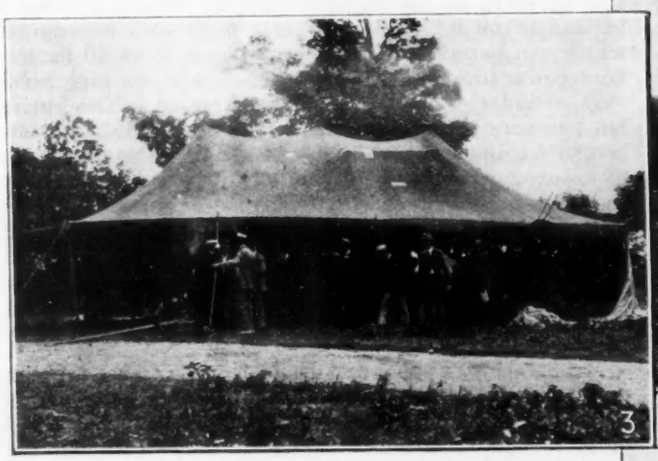
It was voted that the three members at large be as follows: W. P. Kennedy of New York, W. A. Frederick of Detroit, and R. H. West of Cleveland.

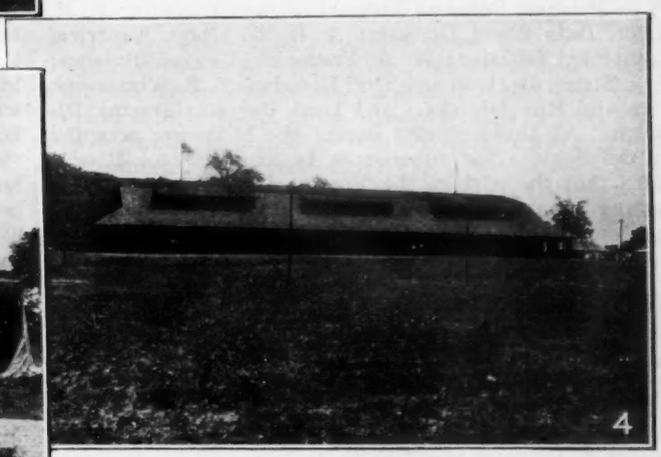
(The Nominating Committee has held several sessions, but has not yet submitted a report. According to the Constitution of the Society the Committee has until Oct. 1 to submit a ticket made up of consenting nominees.)

Amendments to the Constitution

Chairman B. B. Bachman of the Constitution Committee brought up the amendments proposed at the Annual Meeting of the Society, held last January in New York. These were discussed and amended at that time, and were printed in the January issue (page 5) of THE JOURNAL. Since that meeting they have been mailed to all the voting members of the Society. Mr. Bachman







TRIANGLE PARK, JUNE 17 AND 18, DURING S. A. E. MEETING

(1) Parking space. (2) On hill near dining hall. (3)Tent where propeller-making machine was operated. (4) View of meeting pavilion. (5) Line in front of registration booth. (6) Crowd leaving machine-gun synchronizing demonstration

suggested a slight change in Section C22, describing the method by which the proposed Service Members can be transferred to Member Grade. It was the opinion of Mr. Bachman that the clause, "providing he has not previously paid such fee," was unnecessary. It was voted that the amendments, with the change suggested by Mr. Bachman, be accepted.

(According to the Constitution, these amendments must now be sent out by letter ballot to all the voting members, and if adopted by this mail vote they will take effect immediately.)

The meeting voted to approve action previously taken by the Council of the Society, as a result of which 121 members elected during the last half of the 1916-1917 fiscal year would be credited with the dues paid during that half year, on account of the fact that the Society could not furnish them with all the publications to which they were entitled. This publication shortage was due to the great increase of membership during the year.

The final business at the morning session was the report of the Standards Committee. Reports were presented by Chairman C. M. Manly, Aeronautic Division; F. G. Hughes, Ball and Roller Bearings Division; P. M. Heldt, Data Sheet Division; A. D. T. Libby, Electrical Equipment Division; W. A. Frederick, Engine Division; H. J. Stagg, Jr., Iron and Steel Division; C. B. Whittelsey, Tire and Rim Division; and Dent Parrett, Tractor Division. All these reports except the last were accepted by the Society for submission to mail ballot. It was voted that the part of the Tractor Division report suggesting a 9-in. belt limit for 40 hp. be referred back to the Committee.

First Professional Session

At the Monday afternoon session papers were presented by P. L. Scott, C. E. Sargent and W. B. Stout. The first two were printed in the June issue of THE JOURNAL. Mr. Stout's paper is given elsewhere in this issue.

In opening the discussion of Mr. Scott's paper Mr. Kettering stated that many of us believe that all that is necessary to burn kerosene is to put on a carbureter. As a matter of fact, however, dry kerosene vapor, when compressed in a small cylinder, is precipitated when a pressure of about 55 or 60 lb. is reached. The heat on the walls of the cylinders is not sufficient to vaporize the kerosene again, so combustion starts and carbon appears.

In burning half gasoline and half kerosene, continued President Kettering, the temperature of the cylinder must be higher at low load than at full load. He predicted that some day oil engine cylinders will be enclosed in asbestos jackets, just as steam engine cylinders are now. We will then regulate the temperature by external devices. As the engine speed decreases the cylinder temperature will be increased, and when the throttle is opened the temperature will tend to become less.

In response to a question from E. W. Roberts, Mr. Scott said that the shape of the combustion chamber in the engine described in his paper has a very vital relation to the shape of the spray. The former must conform to the shape of the spray, but the spray must not be allowed to touch the chamber. The spray must not be allowed to strike a hot surface because the fuel will then be cracked and carbon deposited.

Mr. Roberts discussed some of his early experiences with Diesel cycle engines of the Junkers type, having two pistons. He pointed out the possibility of securing higher thermal efficiency in such an engine, because of the lower radiating or conducting surface in proportion to the combustion-chamber size in the Junkers-type engine.

Speaking of the balance of the engine, Mr. Roberts said that he had built a four-cylinder 5 by 5 engine of Junkers type. A full-length drawing pencil could be placed on top of its cylinder and would stand there for a full minute and a half. Then, instead of toppling over, it would simply move off the cylinder gradually because of the vibration. The engine was very flexible, and the fuel economy on ordinary gasoline and kerosene was about nine-tenths of a pound per brake horsepower per hour.

The engine of the future, according to Elmer A. Sperry, may be of the compound type, operating on the Diesel cycle. The low and high-pressure gases may then for the first time be handled properly. At the same time the weight per horsepower will be greatly reduced. At present the trouble with the Diesel engine, outside of its extremely low material efficiency, is that since the high pressure part of the card falls off vertically, the work on about seven-tenths of the total stroke is done at low pressures, operating in a high pressure cylinder.

The Diesel engine now used in submarines weighs on the average from 80 to 100 lb. per horsepower. With the compound engine it is possible to have a mean effective pressure in the high-pressure of 300 lb. or above, instead of 90 lb., as at present. With such an engine, which can be made to weigh only from 15 to 20 lb. per horsepower, the mean effective pressure in the high pressure cylinder would be greatly increased. The entire low pressure part of the card would be handled in a low pressure cylinder where it should be; the ratio of volume to exposed perimeter being suited to the conditions, and the pressure at the end of the stroke only a little above atmospheric. In this way, Mr. Sperry asserted, a much cheaper and lighter engine of very high efficiency will be available, burning the heaviest fuel oils.

Second Professional Session

Mr. Stratford's paper and demonstration on the refining of petroleum was the first event on the program Tuesday morning. A complete distillation apparatus and samples of petroleum in various stages were used in giving this paper, which appears on page 69, together with the discussion following it. The morning session was concluded by Fay L. Faurote's paper on Airplanes of Today. (See page 32.)

Third Professional Session

At the final session, Tuesday afternoon, papers were presented by F. W. Caldwell on propeller design, and by Herbert Chase on the modern aeronautic engines. These will be printed in a later issue.

The reports of the S. A. E. delegates to the International Aircraft Conference, held last March and April in London, were presented by title. The reports of Messrs. Clarkson and Manly are given in this issue. L. H. Ehrman has prepared a comprehensive review of the screw-thread situation; this will appear in the next issue.

In connection with the aeronautic papers, Mr. Kettering said that we have not yet reached the commercial stage in aeronautics. The engines cost from $15 to $20 per horsepower, the Liberty engine costing about $6,000. The battleplanes that were flown over the park during the meeting cost about $15,000, that price including the engine, guns and other equipment.

Before the airplane can become a commercial proposition it will be necessary to have a satisfactory engine

NOMINATING COMMITTEE IN SESSION AT TRIANGLE PARK

to sell for, say, $5 per horsepower, and it must be possible to decrease considerably the cost of operation. At present, a field, hangars, mechanics, extra engines, and other things are required, so that the expense is almost prohibitive.

There was not sufficient time for the symposium on tractor design, so that the session was concluded with remarks (given below) by Mr. Kettering on some present problems encountered in tractor design.

Just before adjournment the following "farewell" message was delivered by President Kettering:

"There is nothing that I can say at the close of this meeting that will express the appreciation of the Council of the Society for the remarkable attendance that we have had, and for the spirit of good fellowship that has always been present. We have tried to bring together something of an educational value, something of an entertaining value and something far better than that, something to get us to thinking ahead along new lines.

"After this war is over, we will face a tremendous unfolding of automotive industries, and we should look down the road a little bit; if from these meetings we have gotten something of immediate value, if we have gotten some entertainment, if we have made new acquaintances, that has been fine, but I hope that we will all go away with just a little bit bigger and broader conception of what the automotive industry is and what a tremendous future possibility it has."

Tractor Engineering Possibilities

By PRESIDENT C. F. KETTERING

PART of our program was to have been a Tractor Symposium, but it is growing late, so that I will just say, on behalf of the tractor engineers, that no one should think that the tractor business is not a real engineering problem. It is an engineering problem of the most intense nature, and some of us will find that it is just about as hard to build a good tractor engine as it is to build a good aircraft engine, because in the former we must consider something that we have never had to before, and that is the full load operation of the engine, in the hands of a man who does not know much about it. For the first time we encounter what is known as psychology in engineering, and find the psychology of the operator has as much to do with it as any other factor.

We can build a tractor and send it out, and a man tries to operate it and does not get good results. We can say that he has not sense enough to operate a tractor, but just remember that that is the type of fellow that is going to be the customer, and we must satisfy the customer. It has fallen to my lot in the last two or three years to have had to do with a problem similar to the tractor problem; that is with a small farm lighting system. That has been about fifty per cent a mechanical and fifty per cent a psychological problem, and we have had to pay more attention to the psychological than to the mechanical end.

We sent out those machines and a man spilt chaff or oats or hay into the gasoline tank and choked his mixing valve, and, of course, the engine would not run. A man can "limp" down to town on three cylinders of an automobile and go to a garage and get it fixed, but he cannot do that with a tractor nor can he do that with a lighting outfit.

The boys used to come back and say, "The fellow put dirt in his gasoline can. No wonder it didn't work." That did not make a bit of difference. The fellow was dissatisfied with his engine. So we said, "Those engines have got to work, even if they are half full of clover seed or oats." It is only lack of appreciation on the part of an engineering department to want to blame the difficulty on the fellow who uses it, when with a little bit of the engineer's own constructive brains the engine could be made so that no matter whether the gasoline was full of wood or chips or anything else, it would burn whatever fuel was put in without choking up the carbureter.

We did that and have had no trouble since. But before we would spend seventeen dollars to take a little bit of cigarette tobacco out of a carbureter. We used a proper number of strainers, and put them in in a way so the owner could clean them himself.

I was born and raised on a farm, and I am trying to operate a couple of farms now with farm tractors. I

find that this tractor problem has not been scratched yet. We have some good machines, but they have not been fitted to the requirements of the American farmer as I know him. We have thought too much of the great, big Western farmer. We have not thought much about the Ohio farmer and the Indiana farmer and the Michigan farmer.

I want to cite an actual case. A friend of mine has two farms of about four hundred acres each in Indiana. Last year he installed tractor equipment on one of them; on the other he kept the horses. He said to me the other day, "No tractor manufacturer on earth could give me a tractor unless he paid me a proper amount for taking care of it. I lost money on that 400-acre farm last year for the first time in my life." Why? Because he broke some gears, and he had no place to go and get them. The factory shipped him the wrong gears the first time. The express company miscarried them the second time, and for two weeks during the important plowing season he did not have that tractor to use. If we do not get the idea of service and the distribution of service parts over the country, and get it quick, we will harm the tractor industry so that it will take years to recover from the effects. There is nothing in the world that is as important as keeping the machines running when they are needed.

I talked recently to a gentleman who had been operating eight or nine tractors, and he said that some of them have been out of service more than fifty per cent of the time. He gave one instance of a drive-gear that had failed. The mechanics worked fifteen hours after they received the new gear before they got it on.

We have been thinking too much in the terms of the automobile mechanic and the automobile repair shop, which we have not got on the farm. We cannot take the tractors to town, but the engineer should go out and see where some of his tractors go, the way some of them are operated, and he will get a real appreciation of the problems in front of him.

The tractor is going to be a tremendous business because animal power for farming operations is going to be antiquated. But let us not stumble all over ourselves. Let us get a veracity club organized for the sake of our salesmen. We have been "overselling" these farmers all the time. We have been selling them a three-plow tractor when it would pull only two plows. It would pull three plows on the right kind of a day, with the weather and the ground just right. The farmers that are getting the tractors are not satisfied because they have been "oversold." They will be satisfied with a two-plow tractor if it pulls that load all the time. We have been overloading our engines. Let us use a factor of safety for the engines. We must standardize them just as we did electrical motors; until electrical motors were standardized on the basis of a rising temperature for a full load, we never knew what they would do.

There are kerosene tractors today that will not run on kerosene; and there are kerosene tractors that will run on kerosene, in which the main bearings must be changed about five times as often as if they were run on gasoline. As engineers, our problem is to make that kerosene tractor a good kerosene tractor and not simply one to "'get by" on. I do not believe that a single tractor engineer is insincere. He is doing the best he can with the experience and the data that have been furnished him. It is a new business, and we must make the mistakes of every new business; but the more quickly we realize what some of the fundamental problems are, the better off we will be.

In the matter of fitting a bearing—suppose we put liners in the bearings. Now, let us go out some day in a wheat field where a man has to take a liner from that bearing and see him do it; then we will wonder that our tractors last as long as they do. We must make things easier to do than we ever thought possible. We have got to study the matter of tools to go with the tractor, how to chain them onto the tractor, so the farmer cannot use them for fixing the binder or the pump. We must print on the handle of that tool what it is to be used for.

We made two sets of tools for our little farm lighting system. On one the names of what that wrench had to do were printed on its side; and on the other there was nothing printed. The farmers would never use a spark-plug wrench once in a hundred times to take the spark-plug out. They could not get the engine apart because they would pick up the wrong tools. Simply putting the names on the sides of those wrenches and tools has saved us worlds of trouble.

The next thing the engineers should do is to write and help write for the sales department a simple common-sense instruction book, and it cannot be seventy-two pages long, because no one will read it. The place to write the instruction book is right on the tractor. If a certain kind of oil is required, print right on the tractor, "Use this oil here," and don't print it in such little letters that the grease and dirt will cover it up, because the man who reads the directions may not be the one who will operate the tractor. The instruction book is not inherited down the line as is the tractor. Therefore, it is important that the instructions go with the tractor.

We had oil trouble on this little farm lighting engine because we thought we had to have a special kind of oil. We found out we didn't after all, but that engine oil is all right.

In Canada they began to have trouble in the cold weather. We said, "In case your oil gets too thick in the wintertime, pour some of the kerosene in the crankcase and it will be all right." It works out fine, and softens the lubricating oil so that it will work around. We have operated engines for months that way and we have never had a bearing burned out. If some one had told us before we tried it, we wouldn't have believed it possible. Now a fellow up in Canada said, "Why not pour all of the kerosene in the crankcase and run the engine off of the crankcase?" Those fellows will think of more things than are in the whole dictionary, and they will try them. We engineers must out-guess the fertile mind of the average farmer when he is in trouble.

There is one thing in the tractor that is not true about the automobile. A tractor pulling three plows in heavy soil doesn't coast much of the time. And while a lubricating system may be fine on the automobile engine, it will not work on the tractor. The atmosphere is not so very clear, especially if the tractor is traveling four miles an hour and a wind of four miles an hour is blowing in the same direction. The problem is a new one; we must go at it in a new way, and get many new angles on the situation.

But there is a wonderful prospect in the mechanical tooling of the American farm for the tremendous work that it has to do. The American farmer has been given tools of an inferior nature. I am not saying this to criticize farm machinery builders; the farmer has demanded such tools for his farm, perhaps because of the peculiar type of competition that has cropped up in the farm implement business. But nevertheless, the stuff that he has bought has been rotten, and everybody who ever worked on a farm knows it.

SOME OF THE SPEAKERS AT THE DAYTON MEETING

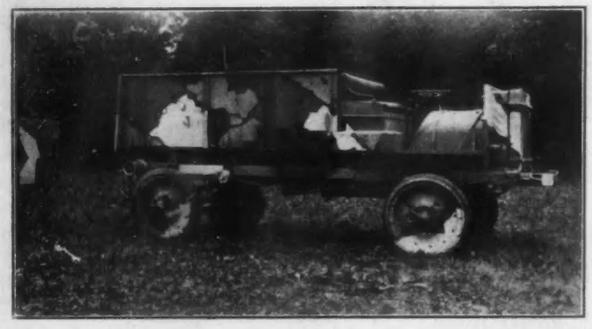
(1) Howard E. Coffin. (2) President C. F. Kettering. (3) Col. E. A. Deeds. (4) Lieut. Mario Miozzi. (5) Orville Wright (6) F. G. Diffin. (7) F. W. Caldwell. (8) Dr. S. W. Stratton. (9) Chas. M. Manly

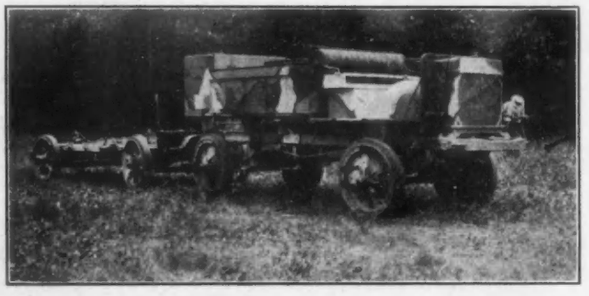
But with the tractor coming on, we must build better farm implements, and they will do for the farm implement business just what high-speed steel did to the automobile business.

I was talking to a certain plow manufacturer, and he told me, "We made a great improvement in our plow last year. We put a roller bearing in the roller coulter." I said, "Well, didn't that add a lot of expense to your plow?" "Oh, well," he answered, "We didn't mind the expense of the bearing so much, but we had a devil of a time to cast the holes in the bearings smooth enough for the roller bearing to work in them." "Well," I asked, "How did you do it?"

He said, "We couldn't do it; we had to use a file." So I inquired, "Why didn't you put in a big drill press and ream the holes?" He replied, "We can't afford to do things like that on farm implement work."

In the tractor development work we must make sure we do not get to making an inferior type of apparatus. The tractors that are standing up are not the cheapest tractors. The tractors that are giving good service are not necessarily the highest priced tractors, but we have to study this problem as we have never studied any problem, because the farmer who has put eight hundred or a thousand dollars into a tractor, is making a tremendous investment, and if the tractor doesn't do what he expects of it, we will hear from him and he will complain a great deal.





FOUR-WHEEL DRIVE MILITARY TRUCKS EXHIBITED AT DAYTON BY ORDNANCE DEPARTMENT

Orville Wright Dinner

NEARLY 1000 members and guests attended the dinner given in honor of Orville Wright on Monday evening in the dining hall in Triangle Park. The speeches were received with the utmost enthusiasm, those present realizing they were taking part in a historical occasion. President Kettering served as toastmaster of the evening.

The others at the speakers' table were Orville Wright; Past-president Howard E. Coffin; Major-Gen. Wm. L. Kenley, director of military aeronautics of the United States Army; Col. E. A. Deeds, Lieut-Col. J. G. Vincent; S. S. Bradley, general manager, Manufacturers' Aircraft Association; F. G. Diffin of the Aircraft Board; Dr. S. W. Stratton, director of Bureau of Standards; Lieut. Mario Miozzi, representing the Italian Military Commission, and Councilor Chas. M. Manly. All of these were called on for remarks during the evening.

President Kettering introduced as the first speaker Fred Rike of the Greater Dayton Association. Mr. Rike expressed the gratification of the citizens of Dayton in having the meeting of the Society there, and said that he hoped the event would occur again soon.

The guest of honor, Mr. Wright, was then introduced, and arose and bowed in response to the tumultuous ovation he received, but made no speech. Mr. Bradley was called on, and expressed his pleasure in being present. General Kenley told how, almost ten years ago, he had seen the first official flight made by the original Wright machine at Washington.

After the dinner was over adjournment was made to the grandstand, immediately below the dining hall, where the members and guests viewed some aircraft films provided by Lieutenant Miozzi.

The addresses given at the dinner by Colonels Deeds and Vincent, Lieutenant Mozzi, Messrs. Coffin, Stratton, Diffin and Manly are printed in part below in the order in which they were delivered.

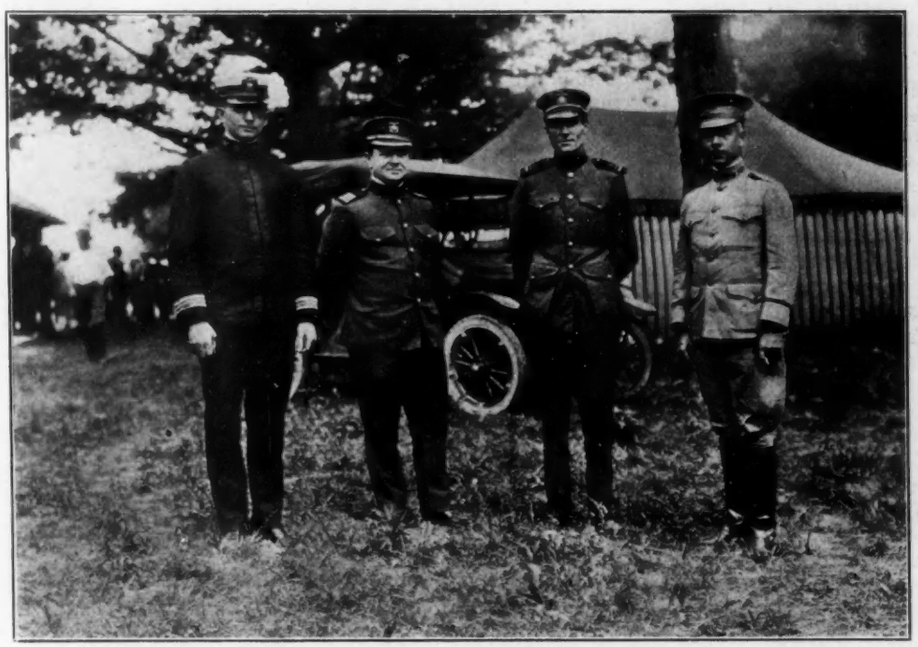
MR. COFFIN:—

THERE is one phase of aircraft work of which nothing has been seen here today, but to which the Aircraft Board's advisory relations were just the same as to the Army's activities. I refer to that of the Navy. The Navy has been building battleships and destroyers and telling us about how submarines have been sunk, but we have not heard a word about aircraft, and yet in many ways the Navy has done the most remarkable work along that line. They are flying every day aircraft weighing up to eleven or twelve thousand pounds, and equipped with from four hundred to eight hundred horsepower, and carrying crews of five men. Within the last week two of these Liberty engines were taken from stock, put into a stock boat, flown up and down the river a couple of times to make sure that everything was all right, and then a trip was made of some 280 miles, from Philadelphia to Newport News, without missing a "shot" on either engine. I have seen them doing this sort of thing right along, and they think nothing at all of it. They are making almost daily trips from Newport News to Washington.

When we consider the size of these boats and the power being put into them, we must wonder just what

the limit in aircraft development will be. Of course, the Army is also at work on large machines, but the Navy, because of its work in detection of submarines, has started immediately with the large sizes. The new Naval aircraft factory at Philadelphia has a floorspace of about three-quarters of a million feet, and the work being done there is something that every S. A. E. member ought to see. All of us, I think, today have seen enough of an exhibition of flying to know that the building of service machines is now under way.

It has only been a few weeks since some of our friends were talking about one airplane that had cost



NAVAL AIRCRAFT REPRESENTATIVES AT DAYTON
Left to right: Naval Constructors S. G. Coburn, N. S. Westervelt, Lieut. J. L. Breeze and Major G. R. Wadsworth

$640,000,000. Part of the press seized upon the expression as a headline and some of us have seen cartoons with the $640,000,000 in one half of the scale and one poor little airplane in the other half. As a matter of fact, only about a half of this appropriation made to the Signal Corps was for the purchase of aircraft and only half of this has actually been spent. Every dollar of that amount has been accounted for, of course, through the accounting system of the War Department. Some five or six thousand training machines have been built and a couple of thousand machines perhaps of various kinds purchased in Europe. Construction in Europe has been delayed because of the unsettled conditions over there, owing to the drives in Italy and on the West front, and to the shortage of materials.

Some 150,000 men are in training in the aviation service in this country, and there are twenty-five or thirty of the big training stations in operation. The Governmental laboratory in operation here in Dayton is one of the most remarkable engineering developments of the whole air service. Perhaps most important of all, the mystery of aircraft production has been thoroughly exploded.

Plants in this country are producing, and others will produce, aircraft of standardized interchangeable designs, nearly as easily as American plants have ever built high-grade automobiles. Those who visit the Dayton-Wright plant will see a fine example of this work and of the interchangeability of parts. Airplanes are being shipped from this country in a disassembled form without special assembly markings. The crates, when received on the other side, can be opened and the standardized parts assembled without any regard to the building operation on this side. As I remember, a cable received only a few days ago stated that within a few hours of the receipt of a certain shipment upon the other side planes were assembled and the engines running.

That is the way in which America will build airplanes. It has taken time to build the tools and the fixtures that have made it possible to manufacture interchangeable parts. S. A. E. members with their knowledge of manufacturing and repair problems will realize what engine construction and airplane construction mean when it comes to keeping these machines in operation at the front, three thousand miles away, because no matter how many airplanes we ship to Europe, if the interchangeable repair parts are not there, and if the men skilled in maintenance are not on hand, the machines will do us little good.

We have heard a great deal said about the possible time loss in developing American engines when it was seemingly so easy to adopt foreign engines, bring them to this country and put them in production, but if anyone will show me a factory in this country that has adopted a foreign engine and put it into quantity production in less than from one to two years, then I will grant that the argument may have some force. I might ask Mr. Houston to tell you something about the Wright-Martin experience. I think an order for engines for the French Government was nearly eighteen months getting into production and a year behind the estimate in delivery.

(In response to a question from Mr. Coffin, Mr. Houston stated that the time mentioned was correct.)

Just a year behind the delivery specified, although the drawings, the engineers and the sample engines were all brought to this country when the work was started. The General Vehicle Company might tell about the Gnome experience, and I know that the treasurer of the American Locomotive Works, who is here, can tell a sad story about the Berliet.

Those who have seen the engine exhibit in the pavilion realize perhaps some of the reasons for the Signal Corps' hesitation in adopting certain engines when the great point was speed and quantity in production. After analyzing the situation and past experience from start to finish it was decided that with American engineers working in the American way and with American machine tool designers working with these engineers, results could be gotten months earlier than if foreign engines were

put into production in this country. I think it is a fact that can be borne out by any representative of the British service here that after three years of war, with some ten thousand employees in the main works, the leading British company is producing fifty engines per week, each of which develops 50 hp. less and weighs 100 lb. more than the Liberty.

Now that gives a little insight into some of the arguments leading to the design and putting into production of the Liberty engine. It is America's purpose to build engines not only for our own Navy, our own Army, but for foreign countries as well. There is a great difference between fifty engines a week and fifty engines a day, an output any one of a half-dozen of the plants of this country plan to be producing inside of the next ninety to one hundred and twenty days.

Leaving aside all such accomplishments as increasing the spruce and fir production, the construction of the flying fields, the building up of personnel—and remember, this entire proposition started from minus zero last July—leaving aside all of the accomplishments in the building of plants for the production of chemicals, in building up industries for the production of accessories—and those who have seen the planes on exhibition and who will see them at the Dayton-Wright plant will learn that the engine and the airplane are perhaps the simplest parts of the job—the wireless telephone, bomb-dropping apparatus, oxygen tanks for breathing at high altitudes, electrically heated clothing, generators, flares for landing at night, scientific instruments for recording speed, altitude, inclination, and a half-dozen other things, synchronized machine guns—practically none of these were produced in this country a year ago, and an industry has had to be created in almost every instance.

Just leave aside all these matters and perhaps three major things may yet be mentioned. One of them is the development of the four, six, eight and twelve-cylinder Liberty engines. When I say development of the Liberty engines I mean, as Major Vincent told us in January, the production of a Liberty cylinder, which might be so perfect that it may go through the war without change, and which can be used in any number or combination of cylinders, on such engines as it may be decided to build. Let us call the Liberty engine one great accomplishment.

We have heard a good deal lately about the Irish situation in England and that the linen situation was tied up with it. The English aircraft production was dependent upon this source of linen supply. The development in this country of a substitute for linen made of long staple cotton, which has in actual test been proven the equal of linen, is another of the great accomplishments in the development of aircraft and for the participation of aircraft in the war.

A third one we perhaps had to almost force upon some of our Allies. Because of the spruce shortage we have insisted that satisfactory aircraft could be built of Douglas fir. By necessity our Allies were obliged to begin using fir. The latest experiments in England are said to have now shown that Douglas fir is the equal of spruce, even in some ways the superior, so that very much of the serious spruce difficulty will be removed.

The Society of Automotive Engineers has behind it a great record of achievement. It is one of the few technical bodies which does and which has always done practical things for the advancement of the industries of which it is a part.

Not very many years ago the Society had a membership of less than 200 and a bank account that was a little less than zero. Today it has over 3600 members—the livest and most progressive men of the automotive industries. It has a great future before it. Its work touches our great present national business of war at almost every vital point. In transportation, both by land and by water, in farm and military tractors, in ordnance, in tanks and in aircraft—in all these lines the interests of the S. A. E. are vitally tied up with the governmental war program.

My efforts for the past few months, as you all know, have largely been directed toward laying the foundation for this great new industry of the air which Mr. Orville Wright and his brother have given to the world. I desire to thank the Society and its members for the loyal aid which they have at all times tendered to me in this work. This same unqualified support must and I know will be put behind the new administration in aircraft affairs. As we get deeper into the war the part which aircraft is to play in the determination of the struggle will be found increasingly vital.

COLONEL DEEDS:—

I SHALL never forget that first meeting when I stood before an enthusiastic S. A. E. gathering in the Willard Hotel about a year ago. It is a great experience for a civilian to go to Washington. Colonel Waldon and I were very much like the disk at Coney Island. If one stays in the middle, where he does not do much, it is pretty good, but if he gets out where things are doing it is not long before he finds himself sliding off to the side in an undignified and ungraceful manner.

I will never forget the night when Major Tulasne in leaving Dayton for Detroit with Captain LeGrange, whom many of us have met, said with tears in his eyes, "This war will do your country good if it doesn't cost as much blood as it is costing our home country in France."

If anyone has ever had a sorrow come into his home, some one taken away, he will find something new there, something for the deepening of character, something that seems to give to life a different view from what he has had. I believe that the coming of these casualty lists will bring into our national life a deepening of national character, a regard for others, something of unselfishness, and something of that which makes for greater things. If they do the benefit to this country will be lasting, expensive though it may be.

The S. A. E. has done well and will be called upon to do greater things as this war goes on, and after it is over as well. I know of no organization anywhere that is more cooperative, more unselfish, and has more of this greater vision than this Society.

The great airplane industry is just in its infancy. I asked Colonel Arnold how many miles were flown each day in our schools, and he sent back the memorandum, "Over 220,000 miles are flown each day in airplanes in our training schools in this country." That is per day almost ten times around the world.

All that we hear are the occasional fatalities in great headlines, and never coupled with that is the fact that on that particular day when that aviator lost his life 220,000 miles had been flown.

In the airplane industry we have created something that will last for years afterward. The tractor industry and all of these things in which we are greatly interested will contribute to a betterment in our whole national life. I wish I might tell more of the details

OFFICERS AND SPEAKERS AT THE TRIANGLE PARK GATHERING

(1) Major L. P. Kalb (charge Quartermaster exhibit). (2) Fay L. Faurote. (3) Major M. B. Morgan (charge Ordnance exhibit). (4) C. W. Stratford. (5) B. B. Bachman, chairman Standards Committe. (6) E. H. Ehrman and F. G. Hughes preparing message to overseas S. A. E. members. (7) S. S. Bradley, general manager, Manufacturers' Aircraft Association. (8) W. B. Stout on an inspection trip. (9) David Beecroft (on the left) chairman of the Meetings Committee

of the situation at Washington. I do want to say that through it all we are keeping a sense of humor, which is very necessary. To our friends we need make no explanations, and to other people it does not make any difference.

LIEUT. COL. VINCENT:—

WHEN I last addressed the Society at New York I described some of the details of the Liberty engine because I had secured permission at that time to do so, and because we thought that the time had arrived when we should give more people a more intimate idea of what the engine really was and of the reasons for designing it.

I am not going to talk about it tonight, except that I would like to straighten out one little point which is rather laughable. On account of the newspaper references to the Liberty engine and to aviation matters in general, it has become the thing to ask, "How fast is the Liberty engine?" I think I can best explain that by asking, "How fast would a racing car engine be in a truck?" We can place a high-strung 3000-r.p.m. engine in a light racing chassis and can probably make 110 or 115 miles an hour. Put that same engine in a truck and gear it fifteen or twenty to one and a large load can be pulled slowly, the horsepower developed and the foot pounds of work done being the same in each case, but the result is very different so far as speed is concerned. We could put the Liberty engine in a small fast plane and secure wonderful results in the way of speed, or we can put one or more of them in a great big load-carrying plane and get wonderful results in the way of lifting a big load and carrying it along at a comparatively slow speed, possibly 80 or 90 miles an hour.

There seems to be a general misunderstanding as to the functions performed by the aviation fields located around Dayton. The Wilbur Wright field is strictly a training field. It is true that some other activities are there, but they are all along the training line. The so-called South field belongs to the Dayton-Wright Company, and is used for its own experimental work, although when we have an overflow we sometimes borrow it.

The McCook field with which I happen to be connected is the testing field and headquarters of the airplane engineering department. It is the purpose of this field to test out airplanes, standardize drawings and do anything that is necessary to get an airplane ready for production, whether that airplane be a foreign or American design.

It has been found necessary to equip this complete experimental station just for the purpose of being a bureau of information and a standardization department. We do not do all the work there by any manner of means, but it is our purpose to foster engineering departments throughout the country. So far as possible all the engineering work is guided from McCook field or from the airplane engineering department, so that we may be sure it will be of the greatest value to the Government.

We are asking S. A. E. members to work with us and be guided by our judgment. Wherever it is possible for us to do so, we will tell them why we do certain things. We are simply working at McCook field and with the various engineering departments to standardize one airplane after another and put it in production in such shape that it can be maufactured in the largest possible quantities with the least possible delay.

LIEUTENANT MIOZZI:—

ONLY a month ago I was in Italy. I saw the wonderful enthusiasm of the American pilot pupils we have there in our aviation fields. I came to America and I saw today the wonderful improvements that American people have made in aircraft machines and in engines. I have faith that with those pilots, with such people and with such machines, America can get the glory that she deserves. Vive America!

MR. DIFFIN:—

THE first thing that impressed every one of us on our arrival in England was the whole-hearted hospitality that was extended to us. We were met on every hand by what is spoken of, sometimes not meaning very much, as the "glad hand of fellowship," but we had it there in reality. We had the whole-hearted cooperation of every man that we met, and we met scores of scores of them in every branch of the work that we undertook, and it was wonderfully intelligent cooperation. By wonderful I do not mean anything further than we might expect from our Allies on the other side. We went over to show them something but I think we came back after having learned a great deal from the tremendous aeronautic work that we saw in England and France.

I am going to outline the biggest impression that I got abroad. I feel that in this country we have woefully misunderstood the strength of Germany. I think it is criminally foolish to expect an early close to this war, to expect that Germany can be starved into submission, to expect for one minute that the internal resources of Germany are anywhere near exhausted. The tremendous offensive power of Germany and her Allies was evidenced on every hand by everything we saw over there.

It is ridiculous to anticipate internal revolution in Germany, as long as the Kaiser commands at least 6,000,000 bayonets. It is foreign to the education, to the upbringing of a German to in any way disregard authority. The most amazing thing that I saw was a German prison camp. Around it were a few strands of barbed wire. A boy could have crawled out of it. In there were several hundred German prisoners. I inquired why that was not barricaded. "Why," they said, "the German common soldier respects authority, be that authority what it may. The French officers have told the German soldier where the deadline is and they don't go over it." The German officer is another story. They hold him in with 16-ft. barricades with highly charged wire around the top.

The next thing that we have not appreciated here is the offensive power of Germany in the air. We have all of us read a great deal about superiority in the air. There is no question about the superiority of our personnel, but Germany spent years before this war started, in anticipation of an air war, and those years of anticipation were years of preparation. England and France today are approaching the limit of their aircraft productive capacity. We must increase that capacity and bring what has been the newspaper dreams of the past into reality. One, two, five or ten thousand machines will not win this war for our Allies and ourselves; it will not win it for Germany. The side that puts the greatest number of aircraft in the air the most quickly is the side that will win.

Another conclusion that I reached over there was that the war on land will be largely a deadlock. They may win a few miles, they may lose a few. If we start driving them the other way, it is a long way to Berlin. But we can reach it in a few hours by air, or any part between there, if we only have machines in quantity.

The greatest help toward getting that quantity of airplanes is the education of the people in the United States to aeronautics. One of the biggest men in control of part of the raw materials in this country told me last December, when he saw an airplane fly over Washington, "I believe those things will be of some use." That man controls in the palm of one hand the biggest end of the raw materials that enter into aeronautic construction. I said to him, "Thank God, there is some help, after all!"

Most people in the country today do not know that an airplane is good for anything except for use as a county-fair "stunt." Those people are in Washington and in every other city.

The biggest help that every man in the S. A. E. can be is to go home believing fully in the doctrine that airplanes will not only help win the war but will win it, and preach everything that he has seen in Dayton as applied to aeronautics, the wonderful possibilities, the offensive and defensive power that is in the airplane. S. A. E. members must preach that to every one that they know, every one that they see, all their friends, all their newspapers, and last but not least, their congressmen and senators.

When that doctrine has spread and not until then will airplane production reach what I believe is a necessity—not a few thousand planes but countless thousands. If this war lasts three years more, our fleets of machines will be in the tens of thousands. It must be if we are going to win. Germany is certainly making preparations to reach such figures.

I hope I have impressed the one thing that the members of the S. A. E. can do. With all the knowledge that they have of mechanics, and all the knowledge of the result of that work, if they do one thing—preach aeronautics the length and breadth of the land—they will accomplish something really worth while.

MR. MANLY:—

I WOULD like to emphasize the utmost seriousness of the whole war situation. I do not believe that any one could go to Europe and see the tremendous work that is to be done and not come back with the impression that every one here must realize quickly that this is every one's war. It is not the war of the people in Washington, not the war of any particular group of people, but it is our war straight through, and we must not stand back and wait to be called to see what we can do to help win the war. Every one who has any possible means of helping to win the war should offer his services in the best way to help gain the victory as soon as possible.

We are likely to hear soon some more of the talk that money is being wasted in connection with the aviation program, that one machine has cost $640,000,000 (or it may drop down to several millions after a while), but the important thing that we all want to keep in mind is that the war is costing about a billion and a half dollars a month, that the industrial and economic loss is a great deal greater than that, and that if we burned up a million dollars' worth of airplanes every day for many months, because they had become obsolete, it would be a great deal better for us to produce the best thing that we can at the moment, keeping it up to the highest pitch of production, and so be sure of the greatest quantity of the best things, rather than be caught by the condition described by the old French proverb, "The better is the enemy of the good."

DOCTOR STRATTON:—

IT HAS been my good fortune to follow somewhat closely the development of the whole aviation program. It has also been my duty to be connected somewhat with other programs, and if there is one thing that has impressed me more than anything else in Washington it is the way in which the members of this Society have pooled their issues and come to the front and produced the goods, without any internal friction or dickerings with one another, and that is not found in many other lines. There is great rivalry in some of the industries for some of the pickings around Washington. At the very first I was impressed with the fact that whoever had the aviation program in charge went to the one set of people that were competent and able to handle this great problem.

As I look back over that program and see how the S. A. E. members got together and picked out a few things and stuck to them, it is no use for me to say that that is necessary for production in large quantities. Even some of our friends across the water have not learned that lesson, but it was absolutely necessary, first, to pick the industry that could do the work, and then to settle upon the few good things that could be done.

Well, of course that meant the throwing away of good things in embryo, as it were. We do not know whether they were good or not, but to adopt everything that came along was absolutely wrong if standardization and quantity production were to be had. After these few good things had been selected, it was absolutely necessary to meet many new conditions. I remember a short time ago reading a report by the British War Cabinet, and almost in the opening paragraph the statement was made that no engine after being designed, and the model settled upon, and the orders given, could be put in production in less than a year.

The Liberty engine has been put in production in six or eight months, and it would have been absolutely impossible without first selecting the men who knew what American methods of manufacture were, and without the backing of the members of the automobile industry that pulled it together and made this thing possible.

There is another side to this thing that I would emphasize: Many people forget the fact that our Government is a Government by the people. We hear many criticisms of Congress, and we hear the members abused from time to time, but I always remember one thing, and that is, the members of Congress are exactly what we make them. They are the people that we send there, and if we do not like them, let us send others.

The organization of the disgruntled people, those who have had the good things that have not been accepted by the Government, have been camping around Washington day and night, getting under the shelter of the Capitol, and telling all of these sorrowful tales about how their good things have not been accepted. It is a fact that the gentlemen in high places in Washington do not know what is going on, and the unfortunate thing is that they will not go to the right people to find out.

I have said many times in Washington to people in high places that they ought to go to the right places to find out what is going on and not to disgruntled persons. I brought Secretary Redfield to Dayton, and he was perfectly amazed at the development he saw here. He

has been telling about it ever since. I understand that some visitors* were here the other day. I think that will do the people here good—and I think it will do *them* good, also.

It is a good plan for every one to see that his representative in Congress is posted. I do not care whether it is engines or matters of Government. That is what they are there for, and those who know the truth of this story ought not to hesitate one moment to tell it to those in authority.

A short time ago I was called before a Congressional committee on matters that have some relation to aviation. I found those members of Congress eager to get the truth, but filled full of the stories that have been circulated by people who either know nothing about the facts or have an axe to grind.

I have assisted in the development of some of the materials and devices that are needed for aeronautic purposes, and I have been amazed at the way people of this country have risen to the situation. They said in the beginning, "We cannot construct this large quantity of airplanes for the want of linen." Now the cotton manufacturers have produced a cotton fabric. They said there would not be enough spruce. There are things that have taken the place of spruce. And if all the spruce and all the fir and all the other woods should pass away we should make them of metal. We thought we would have to go abroad for acetone and other materials, and we are producing them all in this country. There is not a single thing that we cannot produce, but if we cannot produce it we will find a substitute.

I want to thank you for the privilege of meeting once more with this Society, which I have always said was the most progressive and up-to-date of any of the engineering societies.

CLOSING REMARKS OF MR. KETTERING:—

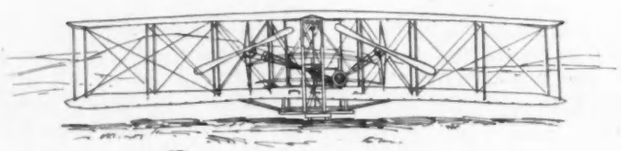
WE sometimes think a thing ought to be a certain way, and it is not that way, and then we are surprised. Up in the country where I come from we have some very peculiar people. My father and I were plowing corn one day, along the road, when a farmer came driving up in his wagon, and stopped, as farmers do, in order to talk about things. He said to my father, "Jake, I sold my hogs today." My father said, "Did you? How did they weigh?" "Well," he said, "you know, they didn't weigh as much as I thought they would, and I didn't have any idea that they would, either." That is about how positive many people are in what they think. We have had a great deal of that with which to contend.

We have had a wonderful meeting today, and I think we have all had a good time. One thing we ought to do is to get the information that has been mentioned here tonight out to the people at large. We have two great assets in this country—one our natural resources, and the other our manufacturing ability to reproduce interchangeable parts in tremendous quantity. If we are to give to this country the full measure of our ability, the full measure of our manufacturing power, we must show the people in authority at Washington that we must settle down, make a few things and make them in tremendous quantities. If we do not do that we will waste time, we will have more investigations, we will have a great deal of trouble, and in the meantime the Hun will keep on "Hunning."

The thing for us to do is to get people to understand what the real manufacturing problems are. I do not believe that anybody has the slightest conception of the tremendous amount of preparation that is necessary to produce a Liberty engine or an interchangeable airplane, and until they do get that into their minds they will never quit talking about "we oughtn't to make this, but we ought to make that." What is the difference, if we have a tremendous quantity of the good rather than having none of the ideal.

There is not a manufacturer who has had anything to do with the automobile business but what has kept on selling his this year's model, even though he has a better one for next year. Otherwise we would not have had any automobile business. But all the time they were improving the machines, and we have to do that in these tremendous war industries that we are starting. We have to keep on making the things that we are making, and if there is a super Liberty engine, let us wait until we get it before we talk about making it; and if there is a super battle plane let us wait until we get it before we start to make it. But while we are waiting, and while we are idealizing, let us keep our factories running and keep these things that we are making going over seas in tremendous quantities, and maybe after all we will find out that the super thing won't "supe" as much as we thought it did, and that what we are sending over there is very good. I have seen many engineers make an improvement on the automobile, and have more trouble with it than with the one they made the year before.

*Hon. Newton D. Baker, Secretary of War and Gen. Peyton C. March, Chief of Staff, U. S. A.



First Wright Flyer. 1903.

Exhibitions at the Dayton Meeting

FROM the time the "blimp" arrived from Akron on Saturday evening until late Tuesday afternoon, when a demonstration of machine gun firing through a propeller was made, the members attending the meeting had a wonderful opportunity to study war automotive apparatus.

The "blimp" or dirigible started from the Goodyear plant in Akron at 2:30 Saturday afternoon and arrived in Dayton about six hours later; it was met by two battleplanes and escorted to the government acceptance field

CLASS B MILITARY TRUCK

near the Dayton-Wright plant. During the Standards Committee meeting Sunday morning it started back to Akron.

While airplanes are flying over Dayton the greater part of each day, special exhibitions were arranged for the members late Monday afternoon. First to pass over Triangle Park at about 4 o'clock was a fleet of eleven school machines from Wilbur Wright Field. About half an hour later seven battleplanes from the Dayton-Wright factory appeared (three of these, according to President Kettering, were production machines flown for the first time) and flew back and forth over the Park, performing the most difficult maneuvers and at times seeming to skim the tree tops. They flew in battle formation at thousands of feet in the air, then swooped down until the pilot was plainly visible, then traveled upward to loop the loop or do a tail spin—thus the members of the Society saw the latest products of American genius do many of the feats they will later perform at the Front.

In a tent back of the meeting pavilion a propeller-making machine brought from the Miamisburg plant of the Dayton-Wright Company was in operation. The propellers were roughed out on the machine and the final finishing touches put on by hand.

In the meeting pavilion was displayed a most complete line of aircraft parts and engines. The French engines, the Renault, the Le Rohne, two Hispano-Suizas, the German Mercedes, the English Rolls-Royce, and finally an American Liberty Engine were on view. A large number of Liberty Engine parts were also shown. Five planes were placed in the meeting pavilion. Two were of the DH4 type built by the Dayton-Wright Company. A platform was built beside one of these, so arranged that the members could thoroughly inspect it. The original Wright machine, first to fly on Dec. 17, 1903, was on view, as were also a French Spad and a captured German Rumpler. Through the courtesy of the Quartermaster Department of the Army a number of parts of the Class B military truck, such as the rear axle, the engine, etc., were exhibited in the pavilion.

A very complete display of the parts of an airplane was shown at one side of the meeting pavilion. This included a skeleton wing, wing beam and other parts of the plane, such as rudders and control mechanism, wheels, and landing gear.

In a large field across the street from the park were displayed the truck and tractor exhibits. At the last moment it was found impossible to get the Medical Corps ambulance with the new standardized body to Dayton in time, but through the courtesy of Major W. T. Fishleigh of the Sanitary Corps it is described on page 19.

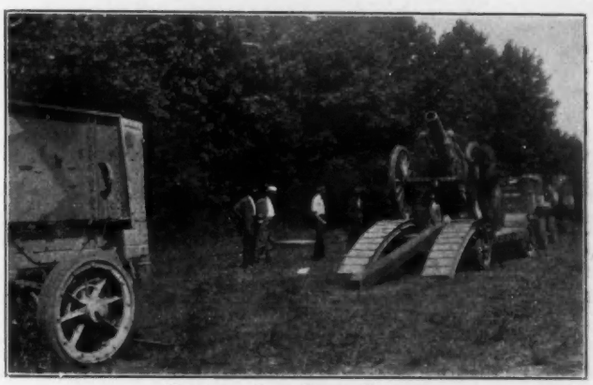
Ordnance Apparatus

The most extensive exhibit of apparatus was made by the U. S. Ordnance Department. The different vehicles are described below. Several farm tractors were operated during the meeting. These are illustrated on the accompanying pages.

The Ordnance Department exhibition included eleven vehicles: Artillery repair truck, equipment repair truck, light repair truck, reconnaissance and machine-gun car, observation car, 3-ton truck-tractor, model 1918, 3-in. gun trailer, 10-ton trailer, and 2½, 5 and 10-ton artillery tractors.

The following information regarding these vehicles has been supplied by the Ordnance Department:

The artillery repair truck carries a standardized machine shop and is furnished for motorized field artillery, ammunition truck companies and for mobile repair shops. The equipment includes gasoline engine generator to furnish power, lathe, bench grinder, air compressor, blacksmith's outfit and an electric drill.

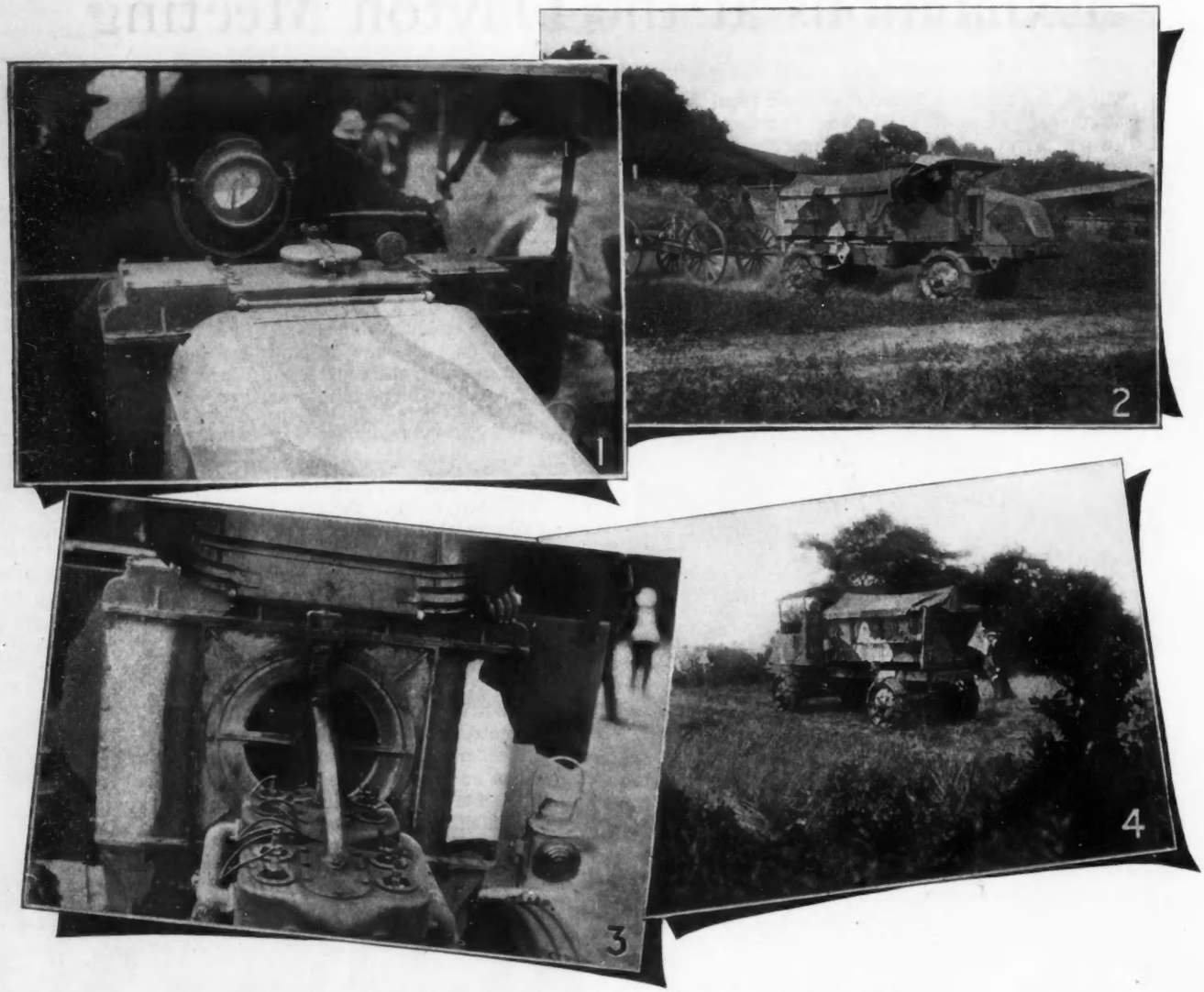


HAULING GUN FROM TRAILER

The equipment repair truck is similar to the artillery repair truck, the same body being used, but is equipped with benches, bins, sewing machines, hand tools for the repair of machine guns, artillery harness, infantry equipment, rifles, and many other forms of equipment.

The light repair truck has a small steel body mounted on a passenger-car chassis. It is used to carry small quantities of spare tools for roadside repair to disabled motor vehicles and also as a delivery truck.

The machine gun car, which has a 1-ton truck chassis, is used to carry the battery commander, range finders and signalling men for motorized batteries together with



VIEWS OF 3-TON TRUCK TRACTOR DEVELOPED FOR ORDNANCE DEPARTMENT
(1) Top of radiator. (2) Hauling gun limber. (3) Top on engine; and (4) Climbing hill

range finders, telescopes and apparatus for control of artillery fire. When issued to machine-gun organizations, it carries the machine-gun personnel and also a complement of machine-gun ammunition, although the guns are not fired from the car, but are merely transported thereon.

The staff observation car has an "oversized" touring body designed to meet the demands of brigade, regimental and battalion commanders of the field artillery. The body is mounted on a high-speed one-ton truck and will carry nine people. Tables are provided for studying maps, and in the rear and on the sides are large chests for carrying telephone and fire-control instruments.

The so-called 3-ton truck tractor (the Militor) was developed by the Ordnance Department to meet the demands of the field artillery in France for a powerful four-wheel drive vehicle for moving guns long distances on good roads at high speed and under conditions when the track-laying type tractors are not required. As a tractor this vehicle is equipped with a capstan and sprags and will use four-wheel steer; by simply interchanging axles this vehicle can be made two-wheel steer for use as a truck. It has been adopted as the standard four-wheel drive vehicle for the Army.

The 3-in. gun trailer is intended to carry the smaller size field guns over good roads. It is fitted with removable sides so that when not required to carry guns it can be used for transporting ammunition or baggage. This trailer has been built because the gun carriages would be damaged if towed behind the trucks at high speed.

The 10-ton trailer is intended for transportation of tractors, wrecked gun carriages, and for other special purposes; it can also be used as a cargo trailer.

The 2½-ton tractor is intended to have the reserve power of a 6-horse team, and also the ability to move at high speed. Primarily intended for hauling wire-laying reels across country at high speed, it is hoped that it will ultimately replace horses for drawing 75-mm. field guns.

The 5-ton tractor is intended for hauling guns of medium weight at speeds of six miles an hour, although in emergencies it can make speeds of from ten to twelve miles an hour.

The 10-ton artillery tractor is similar in design to the 5-ton but is about twice as large and is intended for handling heavier loads.

ORDNANCE APPARATUS PERFORMING FOR S. A. E. MEMBERS

(1) Five-ton tractor crossing soft spot. (2) Hauling limbers with 2½-ton tractor. (3) Five-ton climbing over timbers. (4) Ten-ton tractors, Major Sheridan up. (5) Another view of 10-ton machine (7) French 75 mm. gun. (8) In the thick of the woods

VIEWS OF ORDNANCE AUTOMOTIVE VEHICLES DISPLAYED AT DAYTON MEETING

(1) Staff Observation Car. (2) Reconnaissance Car. (3) Artillery Repair Truck. (4) Ten-Ton Trailer. (5) Equipment Repair Truck

U. S. A. Ambulance Body and Trailers

ORDERS have been placed in two different factories for five thousand of the U. S. A. standard ambulance bodies; this order will cover requirements until next June. It is understood also that the Medical Corps has the privilege of ordering seven thousand more from the same companies. Deliveries will start in August and it is expected that peak production (800 per month) will be reached in September.

A new standard body has been designed by automotive engineers connected with the Sanitary Corps, with the advice of a number of S. A. E. members who are

LOADING LITTER ON TOP TIER

experts on body construction. A spare parts trailer and a field litter carrier have also been developed, both of these being designed to be drawn by the standard ambulance.

In designing this new body, as in the design of other automotive apparatus at the present time, three prime considerations, each of vital importance, were considered: First, the use to which the vehicle will be put on the other side; second, the methods by which it can be manufactured on this side; and finally, that its construction be such as to require minimum shipping space.

The standard body is designed for application either on the ¾-ton G. M. C. chassis now used by the Medical Corps, or on the Class AA, U. S. A. military truck. The body will carry eight sitting and four lying patients. The design has been worked out so that two men can load the litters, instead of requiring three as is the case with the present type.

According to the specifications issued by the office of the Surgeon General, the design is intended to provide a strong substantial motor ambulance body, one that can be readily knocked down and assembled in the shortest possible length of time consistent with boxing of disassembled body in the minimum size of shipping box. The floor, roof, side frames, and division panel, seats, deck frames, etc., are assembled as separate units, complete in themselves. The body is paneled with "vehisote," on the sides and on front division panels. The roof is made up of bows or rafters, center rails, side rails and headers, and the whole is covered with "agasote." The edges of the roof are protected by sheet steel bent to angle form and screwed through agasote and side rails.

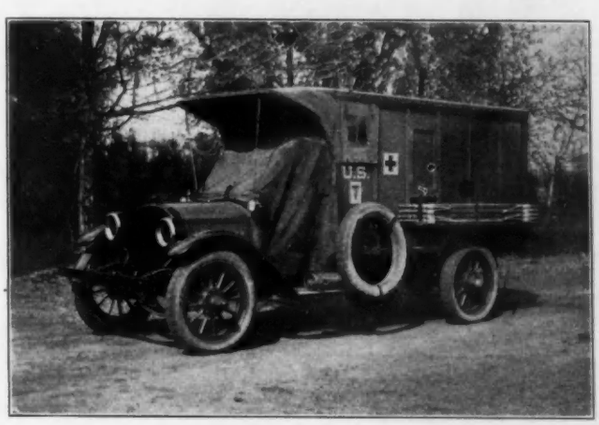
The aim has been to obtain complete interchangeability of parts so that the body can be shipped knocked down and assembled on the other side by comparatively unskilled men. The main parts, such as the sides, floor and roof will be fastened together by bolts and nuts. The body is strong enough to carry the weight of two wounded men at the top. While intended for carrying wounded men, the vehicle can be used for any Ordnance or Quartermaster service that would ordinarily be required of a ¾-ton truck.

The specifications provide that all parts must be constructed to definite standard dimensions, with proper tolerances, so that any of the parts can be replaced, properly fitted and adjusted without requiring additional tool or machine work. All drillings, borings and framings must be made in connection with forms, jigs and templates, in order to insure complete interchangeability. The general dimensions of the standard body are as follows:

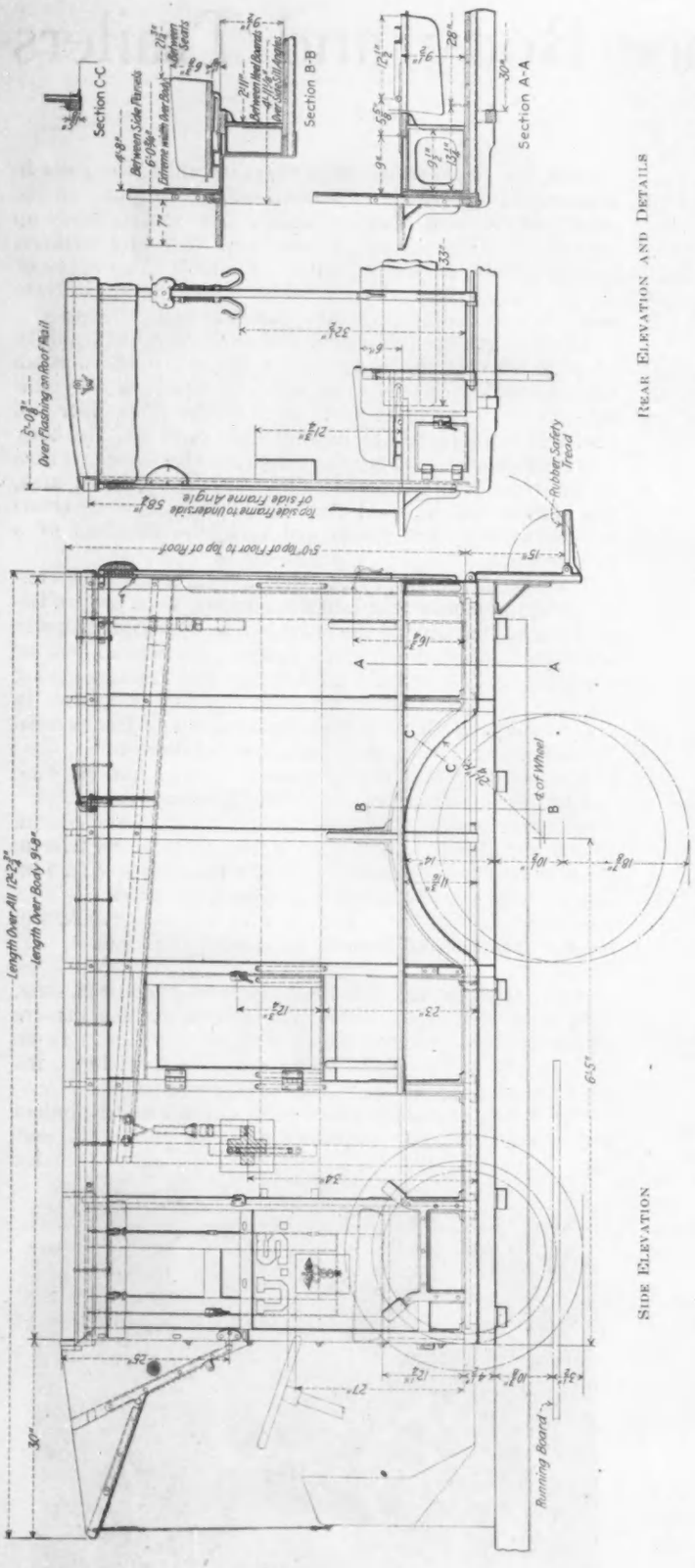
Length of body over corner posts.....9 ft. 8 in.
Length of body from back of front division panel over rear post .....7 ft. 10¼ in.
Width inside .....4 ft. 8 in.
Front corner posts to center-line of wheel house, 6 ft. 5 in.
Height from top of floor to top of roof, at center outside .....5 ft. 0 in
Height from top of floor to outside of edge of roof .....4 ft. 9½ in.

It will thus be seen that the body is roughly 10 ft. long, 5 ft. wide, and 5 ft. high. When these dimensions are compared with those of the packing box, which is 10 ft. 1¾ in. long, 5 ft. 1⅜ in. wide, and 2 ft. 2 in. high, the economy in shipping space can be appreciated.

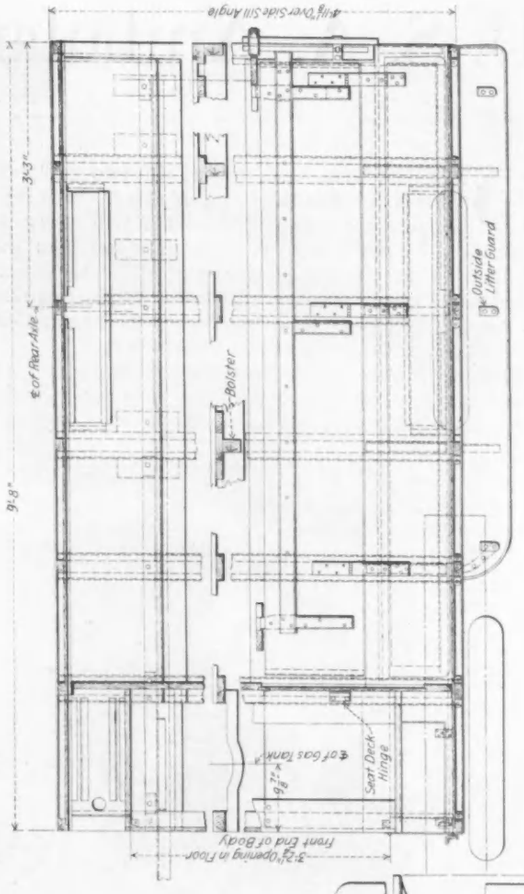
The ¾-ton chassis is practically a commercial product with a few changes made as required by the special service. The speed with the governor off is about 40 m.p.h.;



NEW STANDARDIZED (AA) BODY

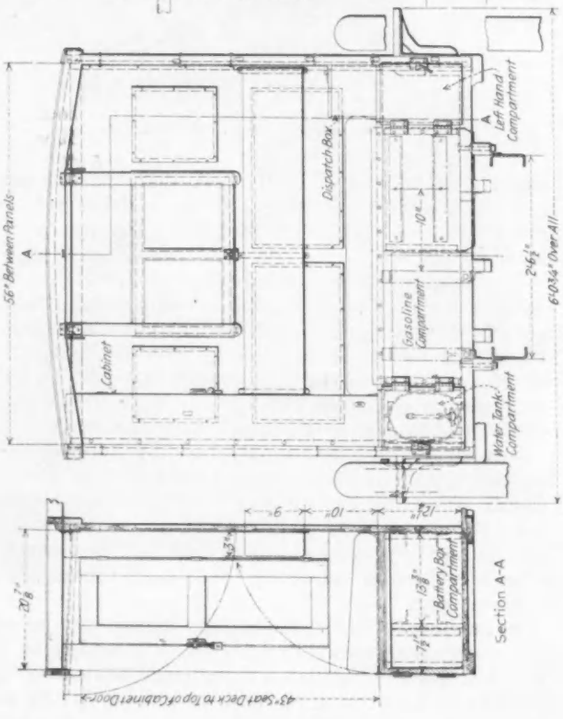


SIDE ELEVATION

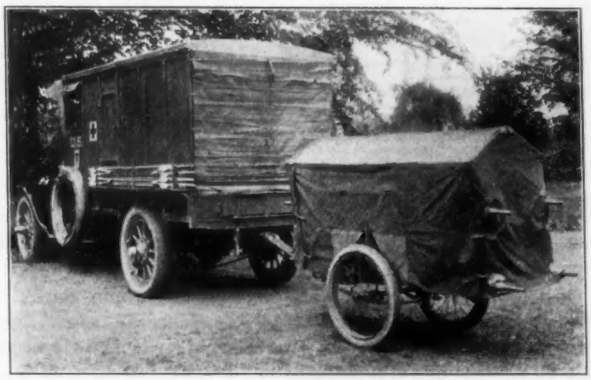


REAR ELEVATION AND DETAILS

PLAN OF "AA" AMBULANCE BODY



FRONT END ELEVATION

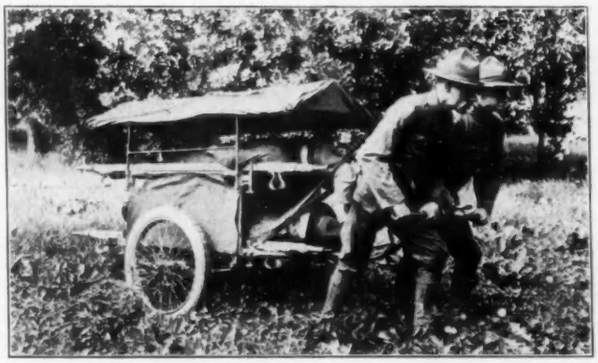


AMBULANCE DRAWING LITTER CARRIER

with it on, about 20 m.p.h.; a four-cylinder engine, giving 27.5 hp. at 1100 r.p.m., is used.

The spring design is especially interesting, since it is the result of a large number of tests of different types. Half-elliptic springs, silico-manganese, graphite-filled, are used, with a heavy type of recoil check or snubber applied to each spring.

The rear springs are 54 by 2½ in., with sixteen leaves. The flexibility is 275 lb. per inch, and the rated load 1350 pounds.



LITTER CARRIER IN USE CONVEYING TWO MEN

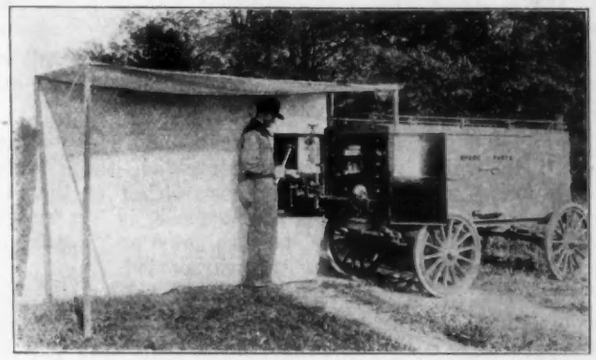
The front springs, 38 by 2¼ in. have nine leaves. These are offset, the distance from the axle center to the rear eye being 20 in.; and 18 in. from that center to the front eye. The flexibility of the front springs is 515 lb. per inch and the rated load 900 pounds.

The total weight of the ambulance ready for the road, without personnel, is about 4820 lb.; allowing for two drivers at 150 lb. each, eight patients at 200 lb. each, including their equipment, the maximum weight of the loaded ambulance is 6720 lb. The weight of the standard body is 1375 lb., and that of the chassis with driver's compartment is 2840 lb.; the remainder of the 6720-lb. weight being accounted for by litters, water tanks and other special equipment.

The spare parts trailer is mounted on a ¾-ton commercial trailer, but the body is specially designed. The body frame work is of wood, which is covered with 20-gage sheet steel. One of these trailers will be provided for every twelve ambulances, so that enough parts can be carried to make emergency repairs on the road. The interior of the body is divided up into thirty drawers. A work bench can be opened out from the rear. A cover is arranged for the man working as shown in the accompanying illustration. Double doors are provided on each end and on each side, giving access to the sheet steel trays and drawers which slide in and out on steel angle guides.

The general dimensions of the spare parts trailer bodies are as follows:

Length of body over all	94 in.
Width of body over all	42 in.
Height of body over all	36¼ in.
Length of lower floor boards	37 in
Curvature of roof	1½ in.

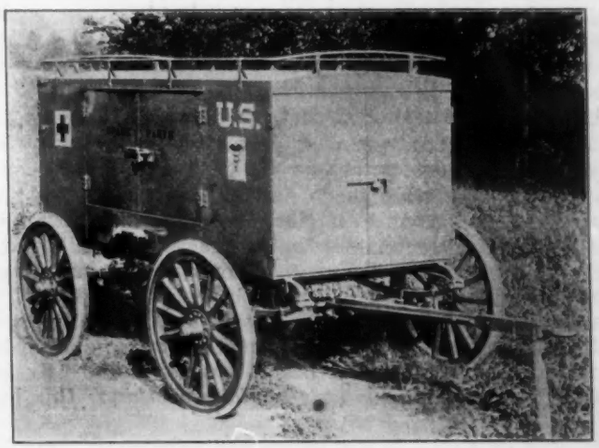


OPENED AND IN USE AS WORKSHOP

The field litter carrier has been designed by the Medical Corps engineers in this country. While the Allies have been using wheel carriers for wounded men, nothing like this has been developed. It is said this carrier will increase the efficiency of the Medical Corps stretcher bearer 100 per cent. Two bearers can draw two wounded men in the litter carrier more easily than they carry one in the litter. The carrier can be hauled over very rough ground. It is designed so that it can be attached as a trailer to the ambulance, thus increasing the latter's capacity 50 per cent.

The two occupants can be completely covered by the curtain, or it can be lifted at the sides, or the top can be moved over to one side altogether.

About 150 carriers have already been ordered for overseas work and it is planned to supply one for every ambulance, except of course for the vehicle in each company used to haul the spare parts trailer.



VIEW OF SPARE PARTS TRAILER

Present Day Problems in Aeronautics

By Wm. B. Stout* (*Member of the Society*)

Semi-Annual Meeting Paper *Illustrated with* Charts

AIRPLANES as at present constructed can never become an industrial proposition or be feasible for commercial work. A radical change in airplane design, if not in theory, will be necessary before air travel, aside from war conditions, can be a commercial success.

This radical change probably will be the result of rational development, step by step, rather than of any sudden revolution in design.

As related to war conditions—the only angle of approach in which we are now interested—these statements are of equal import; for cost, either of the machine or of its operation after purchase, is but an expression of man-hours—the most valuable and important item to be conserved during the war period.

After two years' experience in war, aircraft has become a deciding factor in combat, and it is becoming more probable every day that the present war will be lost or won in the air.

To win the war in the air there must be sufficient dominance in numbers of planes to over-ride enemy territory and demoralize his fighting units, either by direct offensive or by destruction and stoppage of supplies and transportation.

Europe under present conditions can hardly produce a sufficient number of planes to entirely meet the situation.

The solution is *America's problem.*

Every engineering problem at its inception presents certain disadvantages and certain advantages. The engineering result or design must of necessity be a compromise to meet the conditions.

No matter what the final design, it will have certain liabilities as well as assets. He is the best engineer who can design the machine, which, as a result of compromise, has the largest percentage of assets with the smallest percentage of liabilities.

Before analyzing the problems and the possible solutions, it is necessary to look at the disadvantages under which America must work as compared with the Allies abroad, so that our final design may best meet all commercial and shipping requirements as well as those of production and technical performance.

In other words, we must first analyze "what to do" before we can determine "how to do it."

In analyzing what to do we must remember that the technical performance of the plane itself is not necessarily the vital factor, but that production capability and strategic performance may in many cases outweigh technical possibilities. It were better, for example, to build planes of 75-per-cent performance, and ship them abroad, than to spend time attempting to build 100-per-cent planes that we can never hope to build. By all odds, whatever we do, let us *build something;* this has been the spirit with which the American problem has been approached.

In this war it has been possible in some cases to turn engineering disadvantage to strategic advantage. An illustration is the Albatros and other types of planes that Germany has developed.

When the war broke out, the 100-hp. Mercedes engine was practically standardized for German aircraft—and the Hun has constantly adhered to three or four types of engines that he might have quantity even at the expense of quality.

The Mercedes engine as produced was of heavy weight, in comparison with what the Allies were producing shortly after the war was started. It was reliable, however, and the keenly analytical German engineers, being willing to bear with this disadvantage, designed a plane to fit the engine. It was known that the speed of this plane would not be as great as that of British and French constructions, nor would it climb as quickly; it must be able however to fight with a chance of success, the swifter, quicker-climbing Allied aircraft.

Albatros Construction

Time was spent by Germany, therefore, in constructing in the Albatros, a plane that could rise to a tremendous ceiling and, once it attained this altitude behind its own lines, cruise out and over beyond the firing line, but within diving distance of home, waiting for the enemy to appear. This machine was so heavy and so well stream-lined, that it could lose altitude very rapidly. If an Allied plane was unfortunate enough to find itself beneath an Albatros there was small chance of safety in making for home, for the Albatros could dive onto the Allied plane much faster than the latter could dive away, even with its engine to assist, so that although technically an inferior plane, strategically the Albatros was for a considerable period no mean antagonist.

Nor was this the only strategy in the Albatros design. The body was built up of thin wood sections nailed together on laminated wood bulkheads,—a sort of compromise between boat construction and that of the usual airplane body. The struts between the wings were of steel tubing, the spars were of box sections made of small pieces laminated together.

The whole design, while wonderfully trim and, made, one might say, from "cigar boxes and broom-sticks," was as nearly a production job as had yet been devised in wood. With this plane Germany had begun in the air and has kept strategy and tactics a major part of design ever since. This example shows the thoroughness with which the Germans have taken the disadvantages which they had to overcome and made of them an advantage by the way in which they have applied the design.

America, like Germany, has certain definite and deciding disadvantages that must be overcome in its aerial war program,—but disadvantages which the application

*Technical Advisor to the Aircraft Board.

of American ingenuity may even turn to eventual advantage. These disadvantages may be listed as follows:

(1) Lack of airplane manufacturing experience.
(2) Distance from center of operation.
(3) Lack of knowledge of production methods necessary for foreign designs.
(4) Lack of shipping space.
(5) Lack of equipment and organization for testing and research.
(6) Lack of definite knowledge of strategic requirements along the Front.

American Advantages

Against these may be set certain advantages which America now possesses and which we must recognize and put to use just as surely as we must overcome the disadvantages. These advantages may be listed as follows:

(1) Knowledge of quantity production.
(2) Knowledge of value of standardization.
(3) Mass of available data (not being put to use).
(4) *Natural creativeness.*

The solution of the problem by use of these assets is our immediate task. In attacking these items and setting the disadvantages against the advantages to obtain a maximum result, we must remember that time is the factor of greatest importance. We cannot take the time, even now, to learn how to design new airplanes for use on the battle front six months or even a year from now. Our present problem is to take what we have and from it get the greatest possible and most immediate result. This will not mean 100-per cent planes or 90-per cent planes; even if they be only 75-per cent planes in comparative performance, they can be of equal use to 80 or 90-per cent planes, provided they can be had in sufficient numbers.

The one and only *obvious* combination of these advantages and disadvantages is *quantity production* of types of planes already in existence in the United States and of known performance.

Taking the known principles of aerodynamics and performance of planes we now have and developing production-constructions—parts that can be produced in thousands a day, tied up into bundles and shipped abroad for assembly over there—thus we can not only solve our immediate troubles, but lay a foundation for future perfection.

In developing these types of construction—which of necessity probably will be of metal on account of interchangeability—we can at once use that type of American labor found in our automobile plants in producing planes, and thus overcome another present disadvantage.

For 20,000 airplanes, 2,400,000 ribs will be required. If of the usual wood construction, this means that nearly a hundred million pieces must be formed, glued, nailed and screwed together, to say nothing of the inspection and other routine work necessary.

This item alone visualizes what I mean by developing quantity construction, for if we could develop a metal rib stamped out in hundreds an hour to conform to the same aerodynamic and weight requirements as does the wood rib, we would immediately eliminate the necessity for thousands of workmen of the "violin-maker" type who might be put to the construction of other parts and thus add to the quantity possibility.

The more items of airplane construction that we can change from the present hand-made "violin" type of workmanship to designs that are fit for quantity-output methods, as we know them, the sooner we shall complete the program which we now desire.

It is more than probable that we can place a maximum performance type of plane on the battle front more quickly by taking a design and developing it in this production way than by continuously changing from type to type every few weeks, as has been done abroad.

It will not be necessary to explain to the S. A. E. how fundamental this idea of developing production constructions is, and I will leave the idea at this point as a seed for growth.

In attacking any problem for action and for real results three steps are always necessary: First, one must know *what to do;* Second, he must find out by research and analysis *how to do it;* Third, by organization and executive control, he must *do it.* No one of these three divisions can be left out and still get really efficient action.

When the war started, America—owing to the patent situation—had small knowledge of aircraft, aircraft design, or aircraft manufacture. The firms operating were few and of small talent. To enter the airplane business at that time was merely to invest in a law suit.

Strategy and Design

Europe having been at war for some time had developed fighting aircraft regardless of hindrances, and had seen to a certain amount of strategic possibility. In the time available, there was no opportunity for us in America to learn, other than in a perfunctory manner, just what it was we had to do. The Nation and some of its patriots were confronted with the problem of handling all three divisions of action at once, being actually organized and *doing* the job at the same time that they were learning *what they had to do,* and further getting their first education as to *how to do it.*

With all this in view and the confession of a colossal ignorance, not of *anybody* but of *everybody* in America so far as aircraft was concerned, it is a great credit to those who finished the first stage of aircraft production for war that they could do so tremendous a job in so short a time.

When one remembers that within one year a mushroom organization was confronted with the task of spending judiciously more money than was spent on the Panama Canal in eight years, one has a vision of what a real man's job this was.

When one adds to this, the tremendous inefficiency forced upon the organization by past congressional acts, which bound every movement with red tape and suspicion, he sees the task three times as hard to accomplish as though the work could have been done under industrial methods of centralized trusted authority.

That to date in the aircraft program we have accomplished almost the impossible does not by any means prove that our problem is solved. We have spent the time to date learning what aircraft are and how they are being built in Europe. We have had little, if any, time to absorb the necessary lessons relating to production and shipping requirements, which, as we have them, are different from those of our Allies abroad.

With the present type of airplane construction—an attempt to copy foreign designs requiring foreign types of labor—we may never be the help to the Allies in the air that we wish to be. If America is to produce the cloud of ships which she has promised herself to put into the air, other means must be designed for building aircraft than those now existing.

Aircraft design can be divided into four major branches:

First, *aerodynamics* or the air theory of the plane.

Second, *structure*, which has to do with the materials and strengths of the different parts.

Third, *mechanical arrangement*, which is coupled very closely with the first and second branches.

Fourth, *production design.*

A fifth, known as *accessory design*, might be added.

Aerodynamics, in its fundamentals, is very simple. If one advances a flat plane against the air, as in Fig. 1, the center of wind pressure *C* will be at the center of the plate *P*. If this same plate, however, is tipped at an angle and sent forward against the wind, the center of pressure will move forward up against the leading edge.

Since to support an object one must lift it from its center of gravity, this plane at an angle will not support itself, since the center of the weight of the plane is at *CG* or the center of the plate, while the center of pressure *CP* is at the front. This will cause the rear end of the plate to fall, and instead of flying through the air, it will whirl about and fall unless supported.

As an illustration of this try to push a floating board under water with a stick. If we push down near one end of the board, that end will be forced into the water while the other end will still float so that the stick will slide

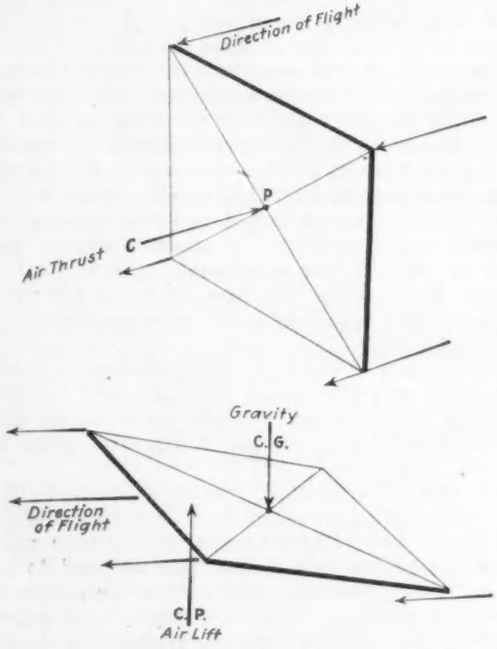


FIG. 1—BEHAVIOR OF FLAT PLANE IN AIR

off the end of the board. If we push to one side or in front of the center of displacement or flotation, the board will go under the water only at the point on which we push, but if we place the stick at the center of flotation of the board, we can push it entirely under the water from this one point of support.

In an airplane, there can be only one center of lift and one center of gravity, so that for free flight and proper balance these must coincide. Thus, in order to make the plate support itself, either the center of gravity must be moved forward by adding weight to the front edge of the plate until the *CG* coincides with the *CP*, or tail surface area must be added at a negative angle to bring the *CP* back to the *CG*. For all flight, it will be seen that *the center of weight must coincide with the center of wind pressure or lift.* In an airplane, in order to obtain flight, the wing surfaces at the front must attack the wind at a certain angle, known as the angle of

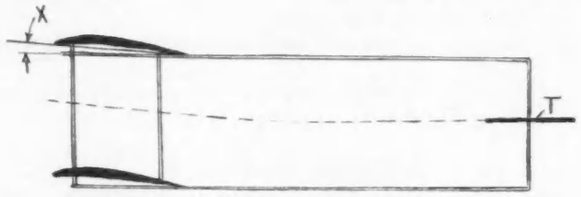


FIG. 2—ANGLE OF INCIDENCE (X) TO OBTAIN FLIGHT

incidence, shown at *X* in Figs. 2 and 3. If left to themselves, the wings will not take this angle, but will merely travel through the air undirected, as does a stick or an arrow. To give them the proper angle of incidence the tail surface *T* is given a negative angle, so that when *T* travels horizontally, the lifting or wing surfaces will be tilted at the certain angle of incidence *X* to give them lift.

Aircraft must be designed for specific uses. In building a boat the designer decides how fast he wants it to go, and how much load it must carry. Immediately he finds that a compromise is necessary, for if he builds a hull to give maximum lift or cargo capacity within its dimensions, he has lost speed possibilities and has produced a slow-going craft. On the other hand, if he designs for speed, there comes immediately the problem of reducing the weight of all parts, fuel and cargo, in order to get sufficient flotation within the dimensions that are required for speed.

The same analogy holds in present-day aircraft, and the wing curve of a plane is a fairly decent analogy to the boat. A deeply cambered or curved wing, of fairly thick section, gives great lift at steep angles, and is ideal for weight carrying. This type of wing curve is shown in Fig. 3. If, however, one designs for speed, he selects a wing better stream-lined and which disturbs the air less at flat angles.

Remember that at speed the pressure on the wing becomes greater per unit of surface area, and as the pressure becomes greater, the plane flies with a smaller angle of incidence.

Thus, when the heavy lift wing, shown in Fig. 3, gets up great speed, it takes a smaller angle and offers at once a great deal of resistance to forward travel through the air. To try to make a wing of this curve travel at speed is just as sensible, as I have said before, as to attempt to crowd power onto a canal boat and turn it into a racing yacht. The addition of power will do nothing but pile up a bigger wave in front of the ship and will add almost nothing to its speed.

This has been proved in certain types of planes; we have replaced 200-hp. engines by engines of 400 hp., but as a result of double the thrust, the gain in speed was only 3 or 4 miles per hour. As a contrast to this, we have taken the same engine in a much heavier plane, but fitted with a speed wing curve, and have driven it at tremendous speeds.

This brings up one of the earliest ideas which was used to design planes for speed, and which was mentioned before the Society last year by one of the speakers* from abroad. Although the heavy-lift type of wing

*Wing Com. J. T. Seddon. (Design and Production of Aircraft in Time of War), S. A. E. Transactions, Vol. 12, Part II, p. 93.

can not be driven to speed by the addition of power, yet the speed type of wing can be driven to greater lift by one of two methods, first by increasing the flying speed, which means landing speed, and second by adding greater area to make up for the loss per square foot of lift.

Racing planes, rather than having clipped wings of heavy lift, tend toward large wing areas and light loading, but with the nicely stream-lined wing curves shown in Fig. 3.

In adding this wing area one must also add more wing area to lift the weight of the wing area he has just added, which is the equivalent almost of a dog chasing his tail. The additional weight per square foot in the wing is around three-quarters of a pound, yet, on account of the extra weight of this new wing surface also, one must figure a weight of 1½ lb. per sq. ft. for all the wing surface added.

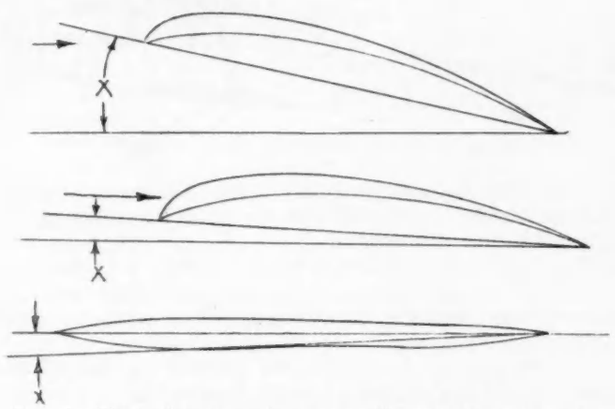


FIG. 3—WING SECTIONS. TOP, FOR WEIGHT CARRYING. AT BOTTOM, STREAMLINE, FOR RACING

Addition of weight on the wings, however, is not of such tremendous importance if one does not increase the parasite resistance, a point I will explain later.

If, however, the designer increase the weight of the engine or body—known as the fuselage—he must add 3 pounds to his total for every 1 pound of additional engine weight, either in extra wing structure, extra tank weight or fuel weight, or added truss. These figures are, of course, structural figures, but I give them to show how closely structural, all the way through, are connected with the aerodynamic considerations, and that in changing the aerodynamic features, one cannot for a moment forget the structural fundamentals that he must follow.

By developing the idea of increased wing surfaces and greater penetration or speed possibility on the part of the wing curve, we have been able to build airplanes of such wing efficiency that the wings have now become one of the least points of resistance at high speed, for the parasite resistance is dominant.

Parasite Parts

Fig. 4 shows the so-called parasite parts of the airplane. These are the parts necessary for structural or operating reasons, but which offer resistance to forward travel without adding to the lift or support of the plane. They include struts, wires, landing gear, radiator, piping, exposed control wires, pulleys, body, tail surface edges, tail skid, and things which to the layman seem so trivial as to warrant no real thought. In a speed plane, however, the exposing of a water pipe from the engine to the top wing, might decrease the maximum speed of the plane 5 miles per hour. Adding streamline wires in the place of round cables might add 10 miles an hour to the speed of the machine.

In speed planes today, at maximum rate of travel, more than 60 per cent of the engine power and gasoline consumed is used up in forcing these parasites through the air, and only 40 per cent of the horsepower is usefully used. It is as though a speed boat going through the water, and having a beautifully stream-lined hull, should be forced to run a race with a log dragging behind, or like a car in a race with the emergency brake set the whole time, wasting power for nothing.

The greatest problem today of the aeronautical engineer, both as to aerodynamics and structure, lies in the elimination of the parasite, or as the British call it, "flat-plate" resistance.

While the airplane today contains essentially the same units of structure as in the beginning, yet the mechanical arrangement has varied as new engines, materials and processes and greater experience in flying have shown the way. The early two-propeller pusher with exposed pilot and no body construction gave way to the single-propeller pusher type with the pilot seated in front of the engine. In case of a spill, however, or a bad landing, the engine had a nasty habit of coming forward through the pilot before striking the ground, for which reason particularly this type of machine was gradually discarded. Another deficiency of this arrangement was that in case of propeller breaking, which happened on the small-engined machines of the early days, the pieces of the blade were likely to cut off the rear tail structure and bring the pilot to serious grief.

Then came the tractor type of plane first shown in the Nieuport monoplane with the engine and propeller in front and the pilot just back of the wings. This type of plane has passed through a high state of development in all sizes within the horsepower limitations of one engine.

With the next new mechanical arrangement first principles were used, two propellers being placed out on the wings and *pushing* the planes. The engines were directly connected to the propellers, and were fitted on the wing. This later gave way to a similar arrangement of the engines, but with *tractor* propellers in front of the wings. Recently we have had planes fitted with many

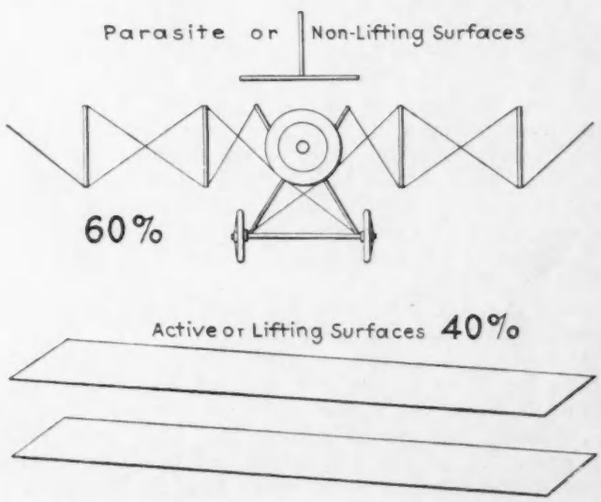
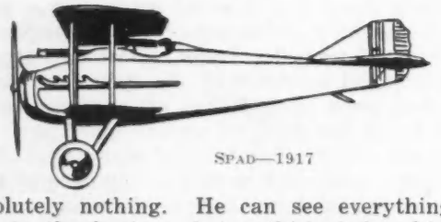


FIG. 4—COMPARISON OF PARASITE AND ACTIVE SURFACES

engines distributed over the wings, each with its separate propeller. Some of these machines weigh as much as fifteen tons.

Outside of engine and propeller location there are three general mechanical arrangements of these tractor planes: monoplanes, biplanes, and triplanes. These types are so well known as to need no further description. The monoplane aerodynamically is the best type of design but constructionally it is to date almost impossible. Requiring double the area in one wing for the propelling of the same spread of wing, the monoplane must either have a wider span or a deeper chord. This decreases the aspect ratio and hence the aerodynamic efficiency. To increase the span of the machine means structural difficulty, as the spars can only be as thick as the wing section will allow and beyond a certain span this construction cannot be built with the factor of safety required in the air. Efficient monoplanes, therefore, are ordinarily flimsy and dangerous for quick evolution, having less space and heavier wing loading than the biplane on account of structural limitations. As a result, they have a considerably higher landing speed, which again makes them dangerous except for the most skilful of pilots.

A big disadvantage of monoplanes in war is the tremendous blind spot under the wings, where the pilot can



SPAD—1917

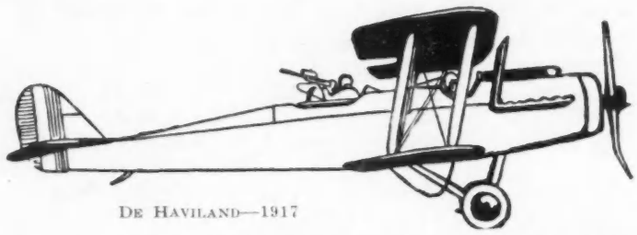
see absolutely nothing. He can see everything above and out to the horizon, but nothing below him. The parasol monoplane developed with the wing above the fuselage so that the pilot can see beneath and above, gives excellent vision but compromises with center of thrust and head resistance in such manner that it is still of doubtful value.

Structurally the biplane is superior and its weight per square foot is far less, but again there is a difficulty of vision. Although the pilot can see more below, since he is farther up from the lower wing and has a narrower wing chord to hide his view, he has a second wing above him which slightly hinders his view, enabling a plane to dive on him from the front along a certain line without its being seen until it is close at hand.

Every blind spot on a machine is dangerous, especially in bombing or combat machines, because the Hun pilot spying a machine from afar and "seeing you first," knows from the make of the machine just where the blind spot is and how he can sneak up under it or around to one side in such a position that he cannot be seen until he opens fire. In formation work one is not permitted to circle around in order to retain his vision in all directions. Over enemy territory, it is important that the pilot keep his place in the formation, traveling and reducing speed with it.

A man in a formation over enemy territory who misses his place in the line and for any reason falls behind is much like a ship which in a convoy crossing the Atlantic has engine trouble and falls away from the protection of the battleships and destroyers. One never knows when a speed scout flyer is hiding in a cloud. The Huns follow a formation fleet across-country as submarines follow a convoy, and pounce at once upon any plane that drops behind to an unprotected position. If one flyer on the fringe of the formation can by attack be forced to dive away from his fellows, he is immediately at the mercy of the Hun scouts, who will not come too close for fear of receiving the combined machine-gun fire of the squadron. If there is a blind spot in the machine, it is possible to force it out of formation.

To permit better vision and also in an attempt to decrease head resistance by the elimination of struts, the triplane has been used extensively. In this type the wing span can be fairly narrow, enabling the machine to land in confined places. The wings are so narrow that the pilot's view is almost complete while the tail



DE HAVILAND—1917

construction is small and short, allowing greater agility for air flights and less chance of the enemy flyer hiding where he cannot be seen.

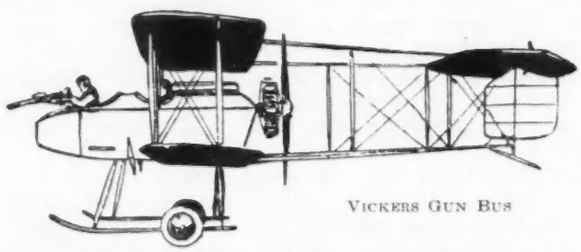
There is no decision as yet as to which is the best type, but in analyzing present-day problems one can suggest the following lines of experiment with each type of machine:

1. How can we overcome the visional and structural disadvantages of the monoplane in order to acquire the aerodynamic advantage which we must admit the bird type of plane possesses?

2. How can we develop the biplane for less parasite resistance and greater vision,—although this type is today in a higher state of development than any other?

3. How can we obtain greater aerodynamic ability of the triplane to fit the decided structural advantages which it possesses?

We may thus run the gamut of experimentation from



VICKERS GUN BUS

aeronautics to structure and back again in these three types of planes alone. And there are others unthought of.

Following this discussion of present possibilities and requirements in airplanes for war and of the next steps to fit what we know to the requirements of today, it is worth while to look ahead to see what the future offers in the eventual development of aircraft.

In the development of the automobile not one-hundredth of the money per month was spent in perfecting models and ideas that is now being spent on airplanes. New automobile models were brought out annually and were in the experimental stage for months.

GERMAN GOTHA—1917

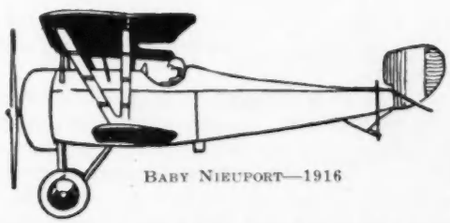
New airplane models must also go through these months of experimental work, but on an average new models and types are taking precedence on the battle front every eleven weeks.

The automobile industry has developed materials and processes, parts and types of organizations through years of effort. In developing aircraft we have all of these related industries and organizations to draw on for knowledge and material. We are thus able to move in development work *five times as fast* as was possible with the automobile, a fact which is worth more that passing thought. This means that the man entering the aircraft industry today *must think five times as fast* as the automobile executive, in order to keep up with the industry, and that an engineer must have five times as much vision and mobility of mind in order that he may keep his place in progress.

A very fine line must be drawn between conservatism, as we have known it in other industries, and what we call conservatism in the aircraft industry. What would be reckless judgment in established industries might well be ultra-conservative judgment as related to aircraft design. It is largely for this reason that during the war period the business man of the old type has been so quickly eliminated from this new industry in favor of that type of man who thinks quickly and fast, and is willing to take long risks, trusting to his own judgment. This type of action necessitates great mistakes as well as great successes.

The British Air Board, for example, was changed five times in the first year of its existence, largely, we are told, because the industry grew faster than the vision of the men then in the Air Board could follow. This work is now entirely in the hands of one man, and a man of quick acting vision and definite commercial experience. That our own program is taking similar form, so far as organization goes, is one of the most encouraging developments of today.

This type of vision naturally requires that research follow every available idea, and research is but a way



BABY NIEUPORT—1916

of "wasting money intelligently." Tremendous sums can well be spent during the next few years in developing aircraft for war, remembering that a day of war saved means a gain of fifty millions of dollars and six thousand lives.

With these ideas in mind it would be well to conclude this analysis with visions fanciful as we can summon to mind, which still are based on sound engineering judgment. From this viewpoint I predict that operating speeds will exceed five miles a minute in airplanes before we can call aircraft really developed machines.

I have discussed the parasite or flat plate resistance as being a fundamental defect of aircraft. Fig. 4 shows the parts that at high speeds now cause the greater part of such a loss.

The solid area in the curve, Fig. 8, shows approximately maximum performance to date. The ordinates indicate the horsepower required; the abscissas designate the miles-per-hour of speed. It is evident from this that above a certain point additional horsepower does not give an equivalent addition in speed, so that even should we double the horsepower of engines in the same weight we would not materially increase the flying speed of a plane as built today, although we could reduce its landing speed.

It is possible to operate wing sections efficiently at a speed of 8 *miles per minute*, as is proved by propeller tips on machines flying at present. The tips on our Liberty propellers travel 8 miles per minute, and their efficiency is nearly 75 per cent. There is no reason, from a pure engineering standpoint, why curves in the form of wings cannot perform equally well. The fundamen-

ALBATROS III

tal difficulty is in landing, for although it should be possible to build a machine today to fly at almost any speed we want, yet the landing problem is so great as to make real speed prohibitive.

If we learn from the German long-distance gun, which sends its shell up from the earth to a point where the atmospheric resistance is negligible, we may also send airplanes to equivalent altitudes, with special engines developed for that work, and thus in a much lighter medium, with less resistance, obtain our speed range. This will require the solving of many problems. It will mean new propelling apparatus or propellers. It may even mean special fuels to be used at altitude.

There are various ways of attempting the problem and as we are gaining experience through actual work at 20,000 feet and over, it is possible and even, in my opinion, probable, that long-distance travel in the future will take place at altitudes more than five miles above the earth's surface. It is as though a ship on the ocean could pick out for itself water of varying density, so that for speed work it would take a medium of less resistance; or to use another analogy—it is like the sea plane, which when its operator really wants to travel fast, rises from the water and ascends into a lighter medium, even though this lighter medium requires greater supporting area. In altitude work, however, this necessity for greater area will be compensated for

by the greater speed, which is the fundamental desire.

Problems in Landing

And so we come to the problem of landing. As soon as we have a plane that we can force to travel at high speed (see the dotted possibility line of Fig. 4) landing will become a dominant problem. We ordinarily visualize safety in landing as depending on speed alone, but speed is only one of the elements of safety. That real safety may be had *three* things are necessary:

1. To land within the smallest possible area,
2. To land on the roughest possible ground,
3. To touch the ground at the slowest possible speed.

It is by no means proved that our present method of landing airplanes is the final one, and intensive study should be put on the development of new landing systems and schemes, that greater things may be accomplished.

Eventually airplanes will land almost in their own tracks, much as a pigeon lands on a window sill or a sparrow on a wire.

In analyzing landing and any one factor concerned with it, the other fundamentals should be kept in mind. Modern speed planes, for example, landing at 50 m.p.h., need a large field in which to alight, on account of the angle at which they come down and the distance they roll after striking the ground. The airplanes used in the early exhibition work flew from and landed in ball parks and four-acre lots, in comparative safety. Present-day machines cannot do this on account of the necessity for speed.

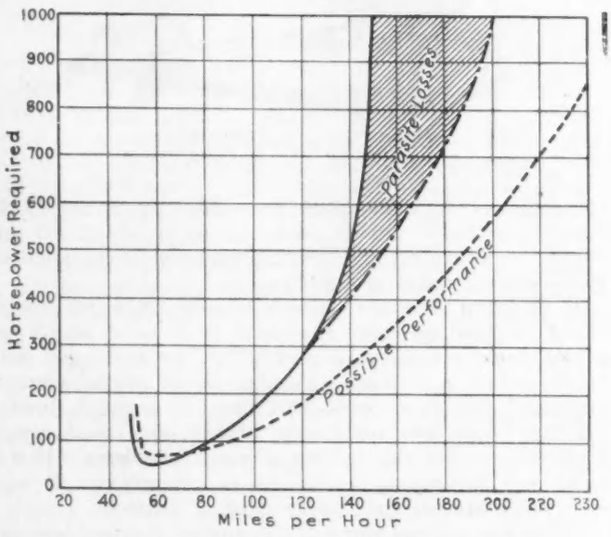


Fig. 8—Maximum Aircraft Performance

Here is a thing that we know can be done, and efforts should be made to increase the landing capabilities and safety of existing planes. All three landing fundamentals require separate study.

Speed in landing is largely a question of wings and their loading per square foot. A plane with a heavy wing loading lands at a higher speed than one with light wing loading. A plane that leaves the ground at low speed generally is hindered in its high-speed flight, and an airplane is too fast to fly only when it lands at a speed that is too great to be safe. Once in the air, flying at a high speed is not a problem but an advantage.

If landing speed can safely be increased to higher limits, then the maximum speed of the plane can be increased in proportion.

Planes with surfaces that are small for their weight glide at a steep angle and come down fast. After they have touched the ground, however, their air resistance quickly stops them.

Planes with light wing loading "float" very easily, coming down to their landing place at a very flat angle. They must travel a considerable distance over the trees before touching the ground and, although they touch the ground at comparatively low speed, they roll a long distance before coming to a stop.

Not long ago I was interested in seeing a landing made by a pilot who had a plane of the "floating" type out for the first time, and who was unused to a machine of light-wing loading. He made a beautiful landing in the center of the field, at a higher speed than the plane was designed to land at, although at the landing speed he had been accustomed to in other planes. Once on the field, however, he had acquired so much momentum that the plane went on and on across the field, until it struck the fence on the far side.

Fig. 9 compares the landings of the slow-speed and high-speed types of planes, it being seen that the high-speed plane, although it strikes the ground faster and at a steeper angle, comes to a stop more quickly and can land in a smaller space.

A machine of light wing-loading, coming into the field over the trees as shown, must float a long distance at a flat angle before it strikes the ground. If the pilot causes the machine to "nose" down sharply over the trees, by the time he has lost sufficient altitude to flatten out he finds himself making a high-speed landing, so that the fact that his machine can land at slow speed has done him no good. After he strikes the ground, as just explained, he rolls a tremendous distance, and is in great danger of breaking the machine, although with small danger to himself on account of the comparatively slow speed.

The problem then is not entirely one of landing speed. No matter what speed the plane lands at, within reason, if the wheels strike no obstruction, the landing is a safe one. If, however, at high speed they strike a hole, or a ditch, or a rut, there is a tendency for the machine to nose over, or even turn a somersault, to the great danger of its occupant. This danger is, of course, less at a lower speed. In other words, in an emergency landing with a high-speed landing machine, there is really less danger of running into objects bordering the field. There is danger, however, of nosing over, if the field is bumpy.

With a machine landing at high speed one can see that having the weight close to the ground would be a considerable advantage, a point that has been discussed somewhat in connection with mechanical arrangements. This indicates a requirement in engine design that has been lost sight of during the early development period when engineers have been learning the fundamentals of aircraft design. This requirement is that the center of thrust due to the engine should be high, or stating it in another way, that the center of weight of the engine should be low, and coincide as nearly as possible with the center of thrust of the propeller, which is, of course, at the engine shaft.

If the center of gravity on an airplane be low, then the striking angle from the point of contact of the

wheels to the center of gravity of the plane, Fig. 10, will be considerable. If this angle is small there is less danger of nosing over. If it is nearly 90 deg. then there will be great danger of a somersault, hindered only by the area of the tail surfaces. A requirement for safe landing, therefore, is a low center of gravity, and large area and leverage of tail surface.

With the floating type of slow-landing machines there is just as much risk of accident with the machine but less danger to the occupant on account of the slower speed.

There is real opportunity for study and research to devise such mechanical arrangements—different from those now in use—as will enable higher speed landings to be made, and with quick stops.

This might be accomplished with a brake, on the floating type of machine. An air brake will not do, as at the slower speeds it would have to present, presumably, too great an area to be effective. A ground brake will not entirely do, because at the time the machine first touches the ground the pressure on the wheels and skid is so small as to be almost ineffective. To apply brakes to the front wheels would be like striking a bump, and would probably mean a spill.

I am not stating how this problem of landing is to be solved. I am merely mentioning it as one of the present-day problems of aeronautics that we can well consider as of first importance.

In studying landing remember that if we can add 10 m.p.h. to our landing speed we can add 20 miles or more to our flying speed. The ideal machine, of course, will be one of sufficient area to make a successful "pancake" landing, but machines with wing loading light enough to accomplish this feat are, with our present knowledge of structure, not within reason.

This brings us to the accessory parts of an airplane, some of which need to be redesigned and others will probably be eliminated.

The landing gear might be called an accessory, and very shortly this will be of the folding type, so that the head resistance can be eliminated, or at least partly so, as soon as the plane has mounted into the air. To date no experiments have developed a structure strong enough and light enough to do this.

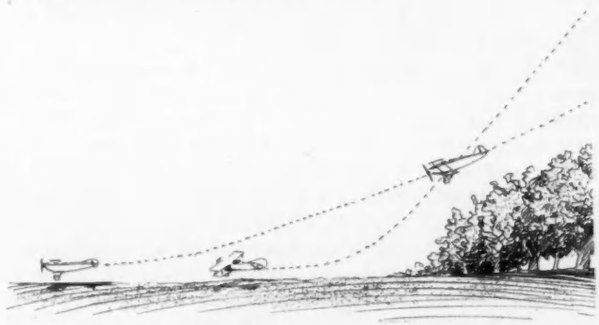


FIG. 9—LANDINGS AT LOW AND HIGH SPEEDS

The matters of armament, or wiring, or carburetion, and of instruments are being taken up, but in spite of their extreme interest have no place in a published discussion at this time.

It is very probable, however, that the airplane will before long be a more accurately navigated vehicle than the ships of the sea.

Very little trouble is had with engines today, either in aircraft or automobiles, and little trouble with planes or with automobile chassis. The main difficulties come in connecting the two; in putting the engine into the plane or the car. As I have stated, we are now getting a great deal of experience in making these connections.

The greatest difficulty as concerns gasoline engines is with the radiator. In order to function properly this must have air and plenty of it, and yet must be so arranged as to offer, theoretically, no resistance to forward travel. It must cool successfully on the ground at 100 deg. in the shade, and within twenty minutes meet the same requirements at zero weather and high altitude.

Recent developments in air cooling indicate that for certain types of machines a great deal will be done with

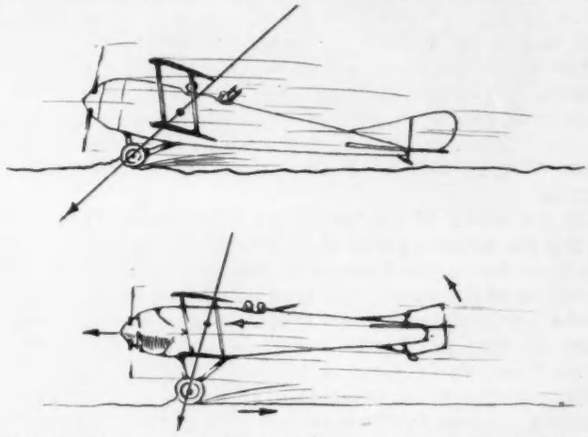


FIG. 10—VARIATION OF STRIKING ANGLE WITH CENTER OF GRAVITY

engines without radiators, there being particular advantage in air cooling for aircraft, in that moderate temperatures are always available in the high altitudes at which one ordinarily travels.

HORSEPOWER-WEIGHT RATIO

The heart of the airplane is undoubtedly the engine, and with this great progress has been made. All discussion of planes themselves, however, has shown that the engine in spite of all has comparatively small influence on speed-range performance. Weight per horsepower rather than total horsepower counts in an airplane, and this also must include the fuel necessary for the type of work that the plane is to do.

Planes with engines of 40 hp. are practically equivalent in climb and speed to planes with five times that engine capacity. The difference comes in the amount of load that can be carried, which again indicates the distance that the plane can travel without refilling the fuel tank.

It is just as foolish to expect a bomber machine to go faster and be more agile than a speed scout, even with its tiny engine, as it is to expect an ocean freighter having engines of tens of thousands of horsepower to outdistance a speed boat with only a small gasoline engine. The difference in cargo capacity, however, is tremendously in favor of the bigger-powered ship. The same is true in aircraft and as progress leads the way and experience dictates, aircraft probably will become larger and larger even for speed performance. Each design will be specialized for its own particular work and have engines of maximum horsepower to fit the maximum load requirements.

The engine, since it was begun in the automobile, is a line of effort in which we have already accomplished much in this country. It is one of the few parts of air-

plane research on which we had data at the start. We have learned much about aircraft engines, however, in the last year. We have learned a number of dynamic requirements which the automobile engineer has never met or had experience to analyze.

Experimentation with engines during the past has followed two major lines: the first aiming to produce an engine of lighter weight for the same horsepower; the second to greatly increase the horsepower for the same weight.

The first school—having its beginnings really with the Gnome rotating air-cooled engine—has developed rapidly, but has been hindered in obtaining high efficiency per cubic inch, in spite of the great number of cubic inches per pound of material. In the second school, on the other hand, as represented by the automobile type of engine, the weight per cubic inch has not been materially decreased, except in proportion to the cubic inches added to the engine, but the power obtained from each cubic inch of cylinder displacement has been tremendously increased.

In the school of engine design now coming into prominence the advantages of the lightest mechanical arrangement are being combined with the better theoretical construction of the automobile type which obtain the greatest power per cubic inch; this school is thus designing what must be very nearly the eventual type of engine, while aircraft are in the form in which they exist today.

One of the most prominent factories manufacturing rotating engines has been turned over to the manufacture of stationary radial engines, this seemingly being the beginning of the end for rotating aircraft powerplants. Radial non-rotating engines of both air-cooled and water-cooled types are worth a great deal of effort today.

Receiving attention in all countries is the finding of some method by which an engine can develop its full horsepower at high altitudes. There are many methods of approaching this problem, and undoubtedly ways will be found whereby powers can be had at altitude equal to those obtained on the ground. Up to date, little has been actually accomplished along this line.

The chief difficulty in obtaining power at altitude is in keeping the proper amount of oxygen in the mixture and the proper initial volume of intake gas in the cylinders. Many methods of pump or turbo-compression and supercharging devices of one kind and another have been suggested, but up to date nothing has been accomplished.

Author's Conclusion

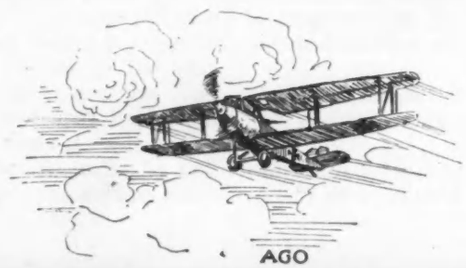
And so I might go on through many fundamentals that have not even been touched on in this paper, and which involve new lines of research and study in materials and processes and the minutest details of construction. Enough has been presented, however, to establish those things that are basic in the future development of planes, and to start discussion to bring out further requirements and possibilities.

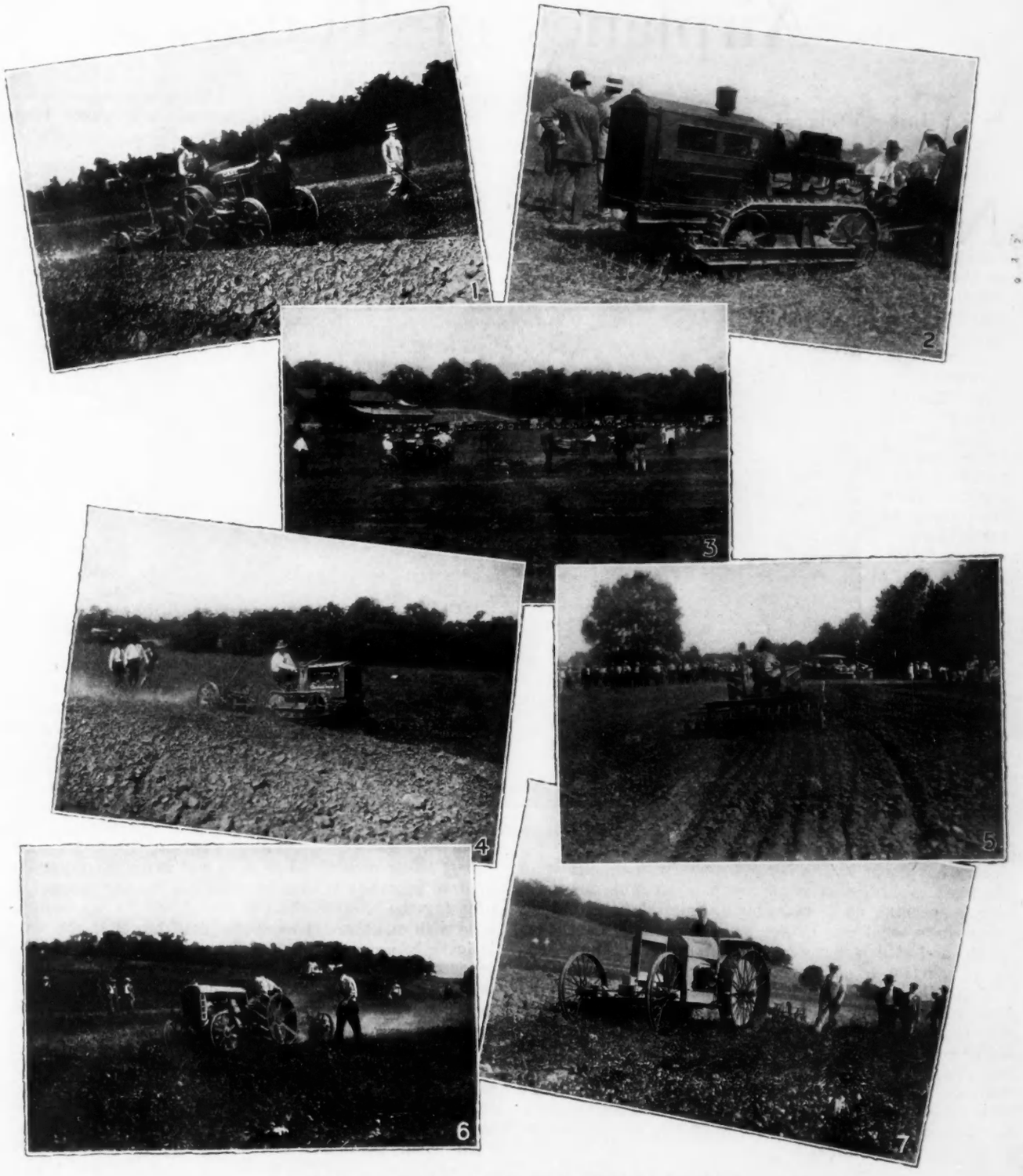
Today we know aerodynamics in America. We know production. We know what to do, and we know, in a large measure, how to do it. The problem is, then, first, to organize the efforts of this Government and this Society so that planes of production construction can be turned out in thousands, in knocked-down form for concise shipment, and put into action as soon as possible on the firing line; and, second, to devise new maximum ideas for the next step. Since America is at such a distance, and cannot hope to produce the latest maximum-performance plane at once, she must therefore at present make up in tremendous quantity for what she may lack in individual quality, believing that a thousand 75 per cent planes are better than a hundred 90 per cent planes, or one perfect plane still on the drawing board.

When the engineers on this type of work have accomplished the result, and our planes are going over by the hundreds each day, and after we have the experience as well as the book knowledge of the intimate problems of aircraft creation, we will be ready for the next step, enabling American ingenuity to build those new planes and more ideal constructions that shall mark the end for Germany in the air.

We are living at the most interesting period of the world's history. We are facing the greatest opportunity that the engineer ever has had for achievement. Europe, recognizing in us the country that has created the submarine, the airplane, the steamboat, and the present major instruments for war, looks to us also, to the country of Fulton, Bushnell, Edison, Langley, Chanute and the Wrights, to create, with that Yankee cleverness which they recognize, the final air instrument for "strafing" the Hun. I am glad to say that America is rising to the occasion, and that our engineers are meeting the situation with remarkable success. Untold numbers of new devices of genius—scientific, accurate and wonderful, are perfected and almost in production, for the demoralization of our enemy, and we can feel confident that every problem which has been given to the American engineer will surely and quickly be solved to the point of action.

Today a world picture is being painted, the background of which has been done blood red by the gory hand of Mars. The paint is not yet dry, and in looking at it one sees only red. There is a foreground, however, which civilization is now painting in delicate colors but with bold strokes, picturing a future of peaceful commerce and generations of happiness. Eventually the background must be covered, but for the time being, while sketching in the detail of that foreground which will be painted, progress seems slow. When the picture is done, however, and the primitive red shall be replaced by the delicate tints of dawn, by the green of the trees and the reflection of silent waters; and when at last the Painter shall lay aside his brush and step back to look over the new world, may He see, through the foreground of happiness and peace and contentment, that middle background of achievement and sacrifice and conscientious judgment with which we are now concerned, as having enabled the foreground of Peace to obliterate the background of War, that Life might take the place of Death, and Love of Hate.





FARM TRACTORS AT WORK IN FIELD OPPOSITE TRIANGLE PARK

(1) Case. (2) C. L. Best. (3) Group of Machines Plowing. (4) Cleveland. (5) and (6) Fordson. (7) Parrett

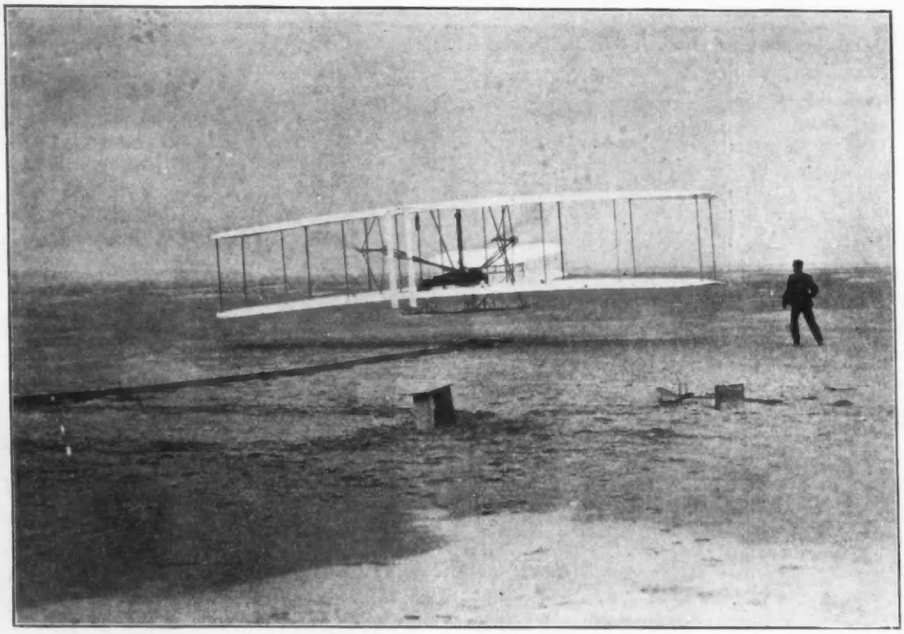
Airplanes of Today

By FAY LEONE FAUROTE* (*Member of the Society*)

SEMI-ANNUAL MEETING PAPER

NO subject, if we are to believe the press today, is of more interest to the world at large, and the United States in particular, than that of aviation. This is naturally so because of its supposed vital bearing on the outcome of the war, and because it bids fair to usher in a new and yet unexplored commercial era afterward.

When the Wright brothers, on Dec. 17, 1903—only fifteen years ago—startled the world by their short but successful flight in a heavier-than-air machine, the most prophetic of us little knew the development that the next fifteen years would bring. The war came, and with it an accelerated progress, such as an industry has never known before, a mechanical activity of the most exciting sort, a marvelous awakening of invention, a speeding up of manufacture almost unbelievable; for despite what our critics say, huge steps have been taken, and still larger ones are in process today. The art of aviation has thrown off its swaddling clothes.



FIRST FLIGHT OF THE FIRST WRIGHT MACHINE, KILL DEVIL HILL, NEAR KITTY HAWK, N. C.

From the frail framework of the Wrights', with its little 16-hp. engine, to the giant Handley-Page, Caproni and Curtiss flying-boats is a far cry. Only a Jules Verne could have imagined or foreseen such an astounding development. War is a hard master, a driver of men and minds, a quickener of invention superlative. To what an extent it has hastened aeronautical development can best be realized by a survey of the hundred years preceding this century.

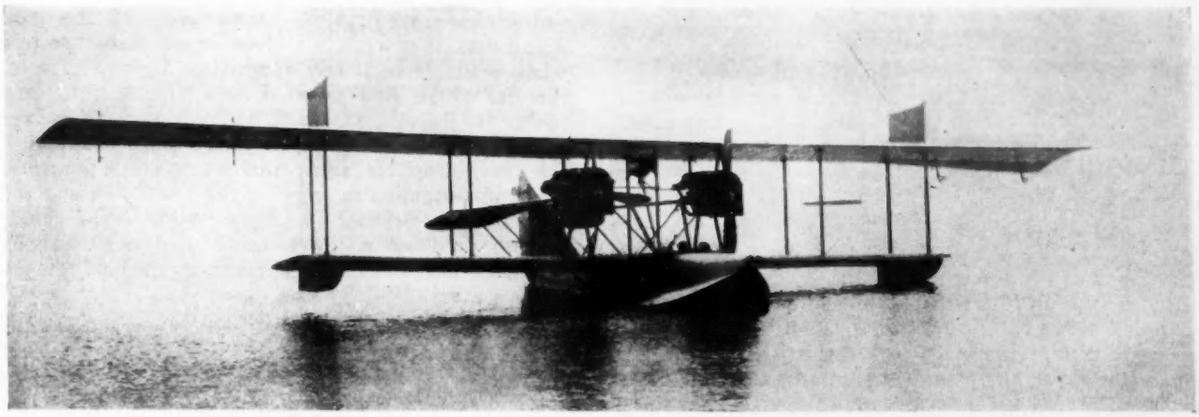
Early History

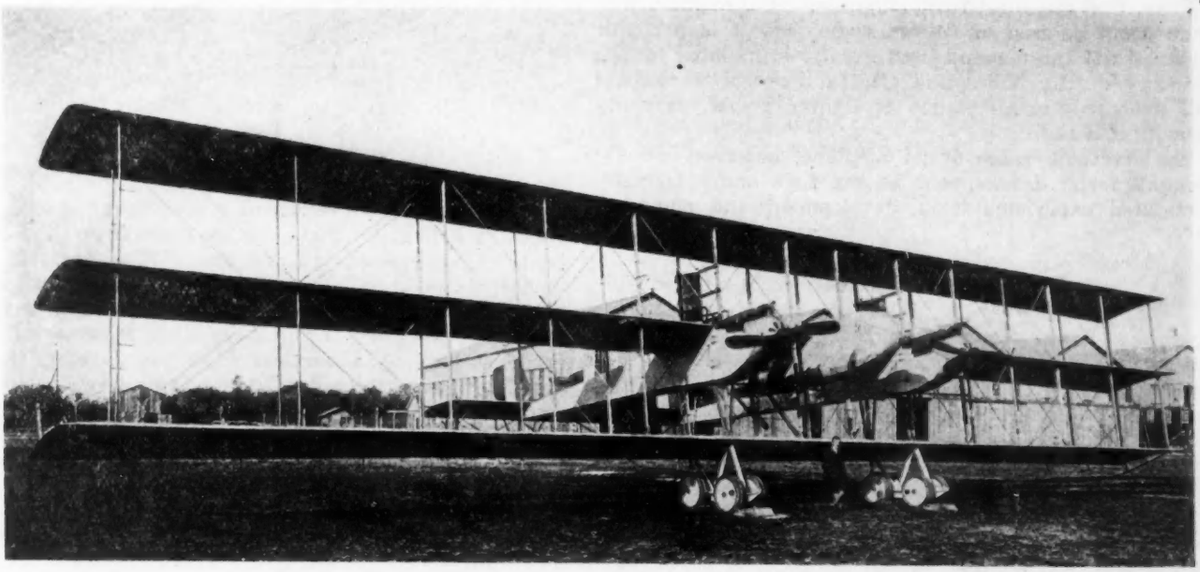
Literature shows us that as far back as the Prophet Isaiah men were thinking about a way to navigate the air. About the year 1500 Leonardo da Vinci and Jean-Baptiste Dante, contemporaries of Columbus, are said to have given serious consideration to the problem of flight, and Dante is credited with having made a successful glide over a lake on a pair of bird wings which he had made after designs of his own.

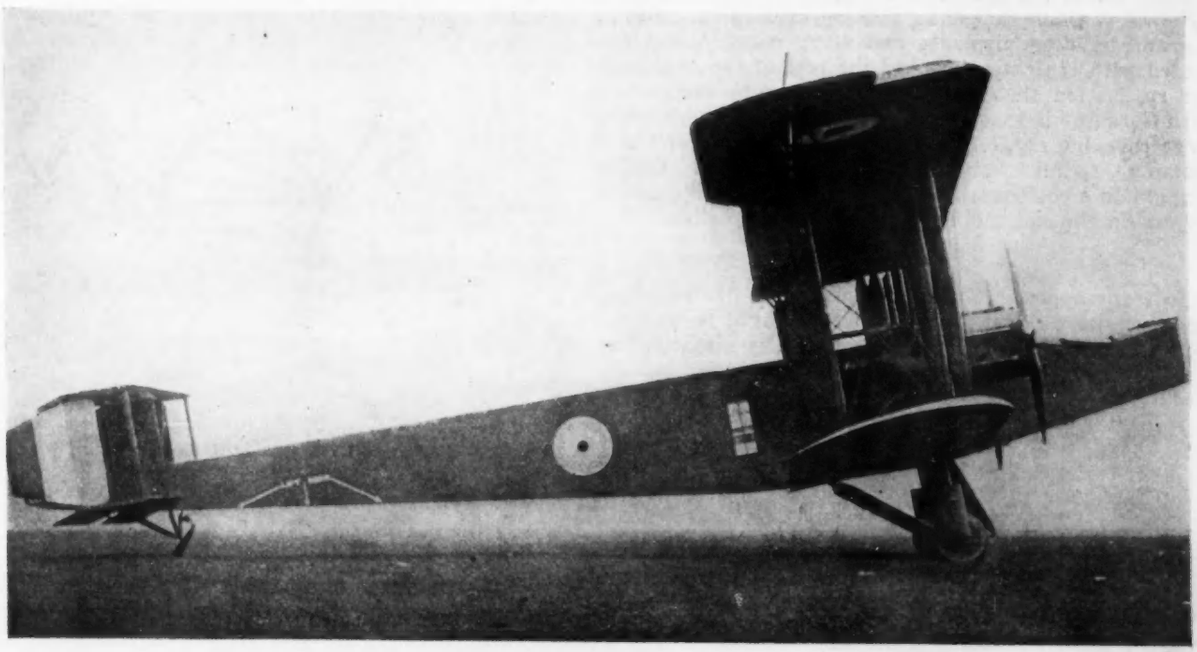
Men of all ages have looked up into the air and wondered how and when they would be able to navigate it. But until fifteen years ago they did not know how. Limitations in their conceptions of time and space prevented them from solving the problem. But now, both time and space, with their attendant dimensional attributes, which are but mental concepts, are slowly being eliminated as man wakes up mentally. Inventive genius is gradually cutting down the one and decreasing the relative effect of the other. As has been the case with all other forms of progress, however, the world is loath to accept the new. The practical plan of a real inventor is looked upon as a fanciful distortion of a disordered mind, and the earthly limits within which the public mind has been content to move give way only under the forced pressure of demonstrated design and practical operation.

It is a curious but natural coincidence that aeronautical development has in all ages followed, or has been accompanied by wars or other great mental awakening. For instance, da Vinci and Dante lived at the time when Columbus discovered the new world. Sir George Cayley, in 1809, made a large glider and with it formulated many laws of equilibrium and control. He was at work during the War of 1812. Henson, Stringfellow, Wenham and Boulton—a quartette of experimenters who also made many valuable contributions to the art of aeronautics—were active just previous to and dur-

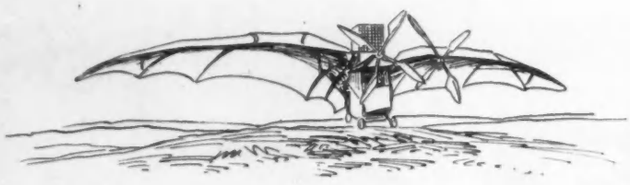
*Manager Department of Welfare and Education, Curtiss Aeroplane and Motor Corporation.







LARGE CURTISS FLYING-BOAT, CAPRONI TRIPLANE AND HANDLEY-PAGE BOMBER

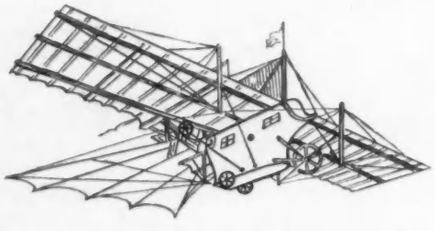


ADLER'S AEROPLANE

ing the War of the Rebellion. Later, M. Adler in France, Sir Hiram Maxim in England, and our own Prof. Samuel P. Langley—then at the head of the Smithsonian Institution—were conducting scientific investigations, and making valuable experiments on machines during the Spanish-American War. This activity culminated in the successful flight made by the Wright brothers in 1903.

From that time until the beginning of the Great War some progress was of course made, but it is probable that had not the demand been greatly stimulated by the necessity of the Allies and Central Powers, we should still have only small planes of limited power, carrying capacity and radius.

The strategic value of an airplane, however, quickly brought aerial development to the fore and artificially stimulated experimentation, development and manufac-

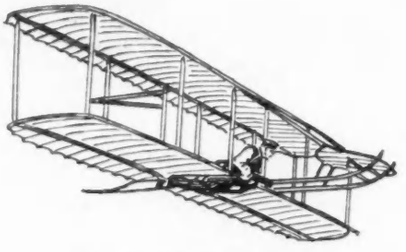


HENSON'S AEROPLANE

ture, first in Europe and then in the United States. The discovery that Germany had for years been planning the building of giant Zeppelins, making aerial maps, designing and building airplanes and every aerial device connected with their use, shocked the rest of the world into the realization that if it were to compete successfully with Germany it would be necessary to build machines of large carrying capacity, of a speedy character and wide cruising radius. The internal combustion engine, brought to a comparatively high state of development by its use in the automobile, rendered this possible.

Conditions in 1908

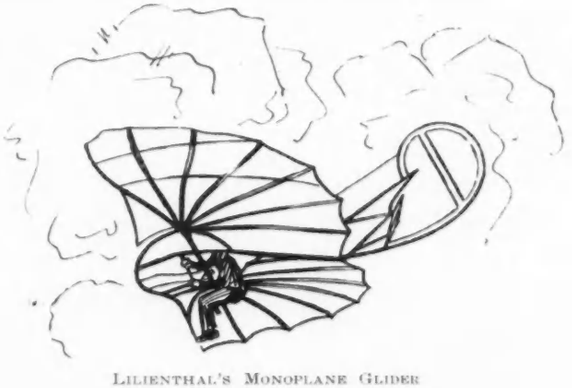
To really appreciate the problems which five years ago engineers were called upon to solve, it might be interesting to take a look for a moment at the situation ten years ago—say in 1908—when most of the American flying machines were in a "featherless state," so to speak; when aside from a few exhibition flights, little of commercial value had been done. The Wright brothers, Glenn H. Curtiss, Chanute, Dr. Alexander Graham Bell, Capt. Thomas Scott Baldwin, Lieut. Selfridge, J. A. D. McCurdy, Charles M. Manly, and a few other pioneers, were all busily engaged in proving the truth of their theories. The Wright brothers had met with some commercial success, and at military trials had demonstrated the worth of the airplane as a fourth arm of the service,



SECOND WRIGHT GLIDER

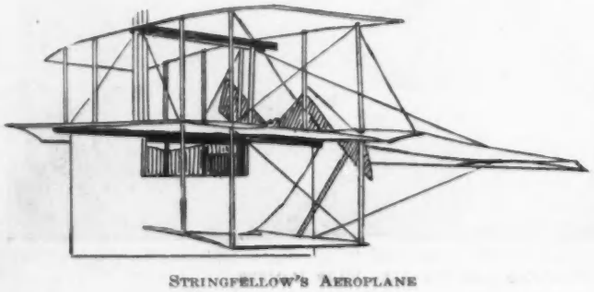
thereby gaining Government recognition. Curtiss and Baldwin had made dirigibles and airplanes and flying-boats of various shapes and sizes. The Aerial Experimental Association had built three biplanes, the last one of which, the "June Bug"—at an official trial arranged under the auspices of the Aero Club of America, made the first publicly advertised flight, in July, 1908. The machine successfully flew 2000 yards over an S-shaped course at a speed of 39 miles an hour.

Later, Curtiss made his famous flight down the Hudson from Albany to New York in the biplane here shown. As most of us no doubt know, there are few landing places between Albany and New York City. One was found



LILIENTHAL'S MONOPLANE GLIDER

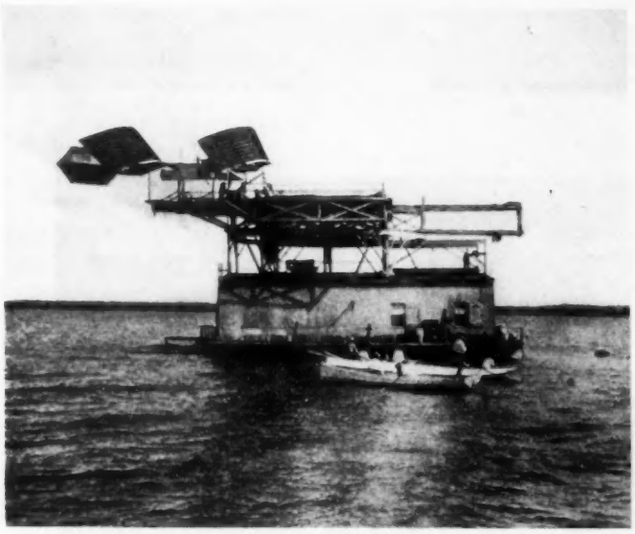
near Poughkeepsie, which Curtiss used on his way down. Fearing that perhaps he might not be able to choose a landing place, and being unwilling to have his machine smashed on the rocks, he had sometime before conceived the brilliant idea of putting on pontoon-floats, in addition to his wheel-landing gear, so that if worst came to worst he could land on the surface of the Hudson River. He said he always had a feeling that water might be safer to land on than the earth, and that at least he could land on the water if he had to without a bad smash-up.



STRINGFELLOW'S AEROPLANE

Birth of Water Craft

This machine, which he later called "Triad," is therefore interesting as a forerunner of the seaplane and flying-boat, both of which developments he later carried to a successful conclusion. On Lake Keuka and on the smooth waters of the Spanish Bight just inside San Diego Harbor, he developed the flying-boat and seaplane. It was here also that he came in contact with Army and Navy. Foreseeing the value of the airplane for army and navy work, he invited officers to be sent



LANGLEY MACHINE READY FOR FLIGHT

to his camp for training, and so during the winter trained many of the army and navy flyers who today are directing the destinies of our aerial forces. It was here also that he flew from land out to a battleship, landing alongside in the water, was hoisted aboard, dropped overboard again, and flew back to land. A year before Eugene Ely had succeeded in flying from land, in a land machine, and alighting on the deck of a battleship. It was at

FIRST BRISTOL (ENGLISH) MACHINE

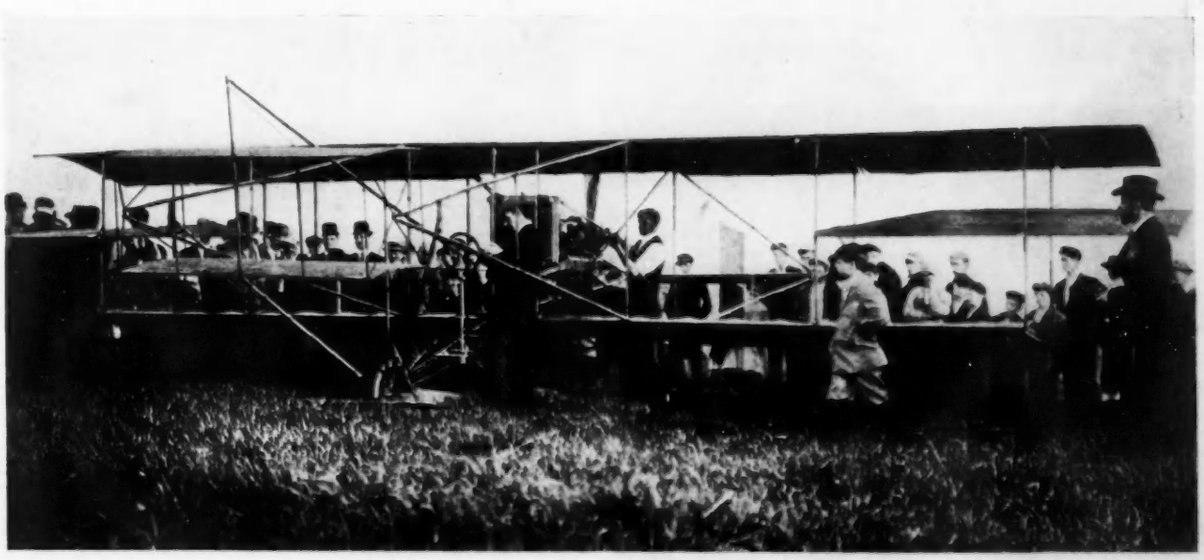
this time that both the Wright brothers and Curtiss demonstrated the possibility of aerial bomb dropping, and predicted the remarkable part that airplanes would play in any future conflict in which the world might become involved.

Early Design

On all these early machines, as we shall see, the pilots sat in an exposed position. Little attention was paid to resistance and stream-lining, and because of the fact that most of the machines were pushers, it was necessary to place the radiator well up to the front and between the wings and put the pilot and his passenger forward. Control systems were more or less fragile and unmechanical pieces of apparatus, designed to suit the purposes of the individual pilot. No attempt, of course, had been made to standardize them nor to work out similar movements for controlling the various surfaces.

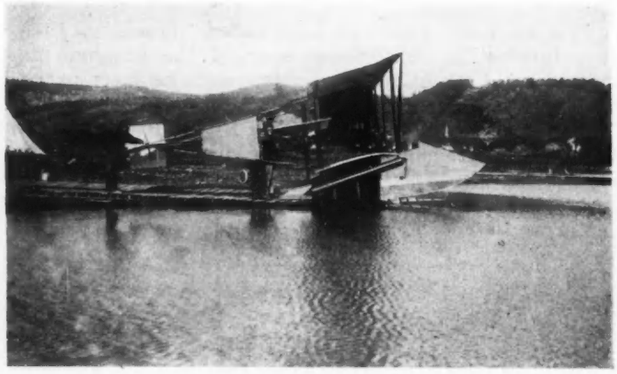
Landing gears differed materially as did the methods of getting off. The Wrights used a form of pylon and counterweight for launching their machine from skids.

The body or fuselage was not inclosed, the struts were not stream-lined, neither was the landing-gear. The rudders were crude affairs, and the wing-panels, judged by

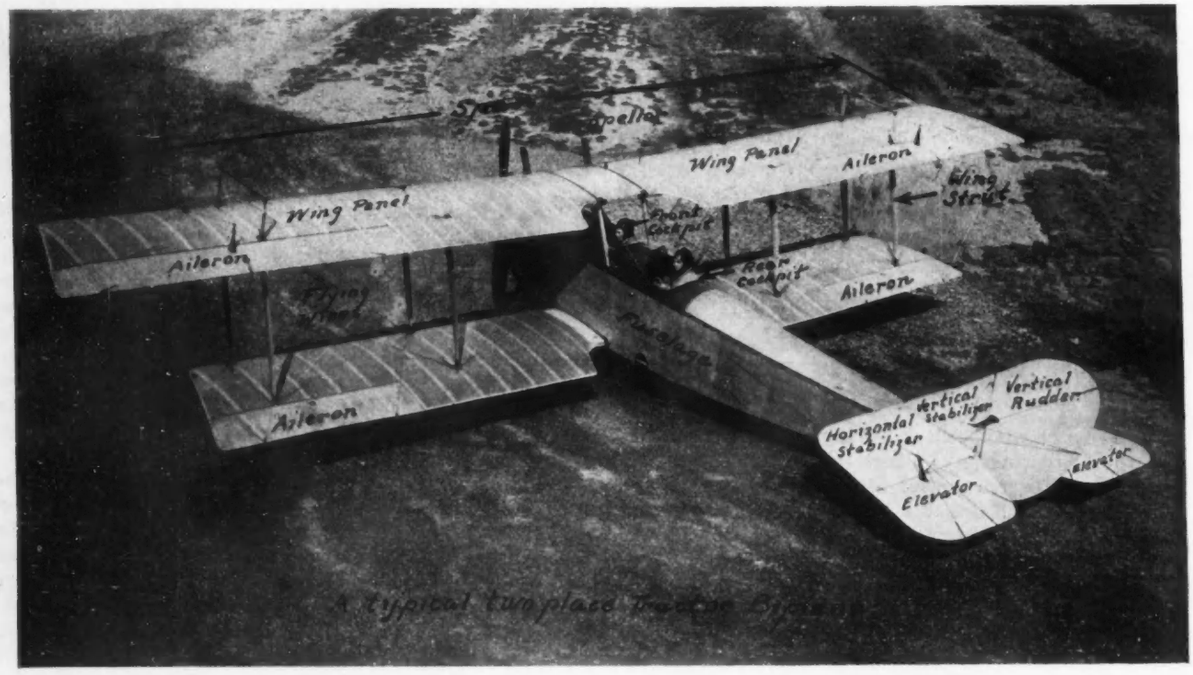


GLENN H. CURTISS—ALBANY TO NEW YORK FLIGHT

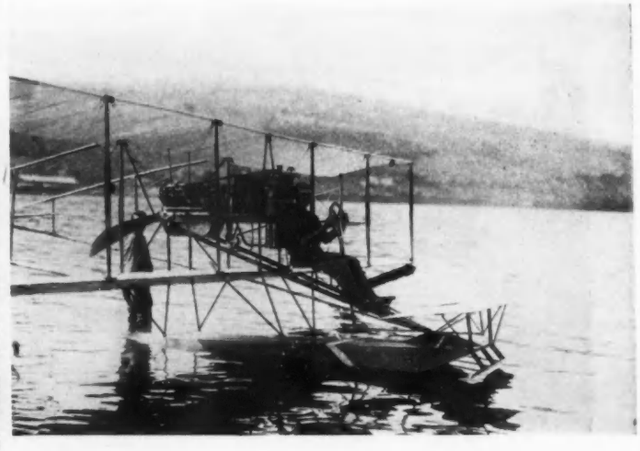
ONE OF THE FIRST CURTISS BIPLANES



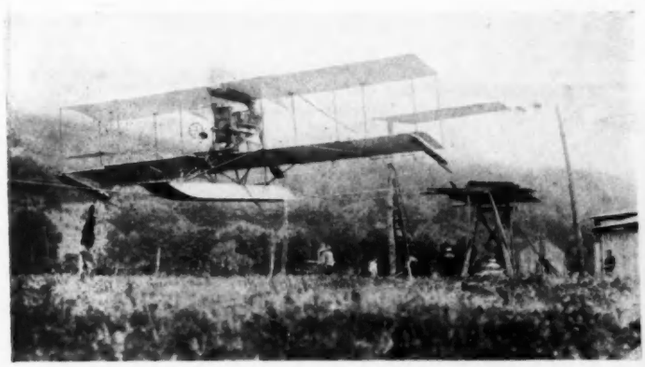
EARLY CURTISS BOAT (AMERICAN)



TERMS IN COMMON USE IN AERONAUTICS



VIEW OF EARLY CURTISS SEAPLANES



LAUNCHING A HYDRO FROM A WIRE (CURTISS)

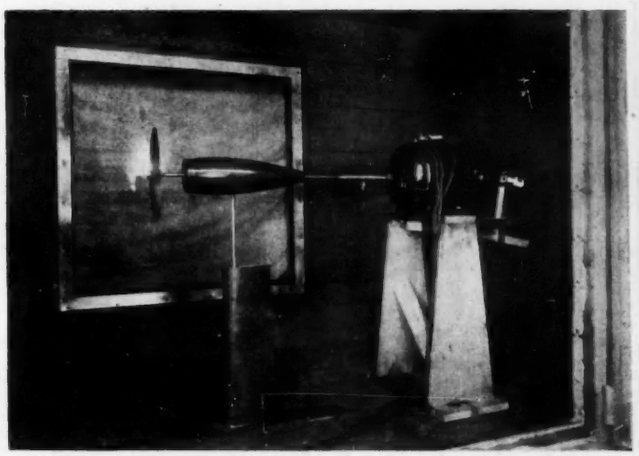
the standards of today, were flimsy things of cloth and sticks.

All praise to those brave men who risked their lives for the development of aviation! To the Wright brothers who—in spite of all odds, laughed at by friend and foe alike, at last had their efforts crowned with success, and from comparative obscurity placed their name, and that of Dayton, upon the lips of the world—I wish to pay tribute.

To me there is always in the character of every pioneer a certain something which inspires a feeling of awe; a certain far-away look, a prophetic cast of the eye almost childlike in its expression, that removes him from the crowd and causes him to be marked among men. It were as if God himself looked out upon the world through the eyes of his chosen few—inventive geniuses, reformers, great minds, they are; where do their ideas come from, where, indeed, if not from Divine Intelligence. Surely no human hand nor mind has trained their cunning. It may have given them their starting point, perhaps, but what of their prophesies, their enlarged views—

J. H. TOWERS AT HELM OF CURTISS PLANE

these alone must come from Above. They are the ambassadors of Spirit, so to speak, the human mouthpieces of Divine Mind, the wideners of the vision of life itself. As such they can no longer be considered as individuals, beholden only to themselves; they are the property of the world, the hostages of society, the almoners of inventive gifts for which the world can never adequately repay them. Modest to a degree, the true genius seldom realizes his mission, nor claims his own until the world, awake at last, honors, alas! sometimes too late to be of any real



MODEL PROPELLER BEING TESTED IN WIND TUNNEL

benefit to him. History alone develops the true greatness of his discoveries and grants to his memory the fitting crown of unselfish success.

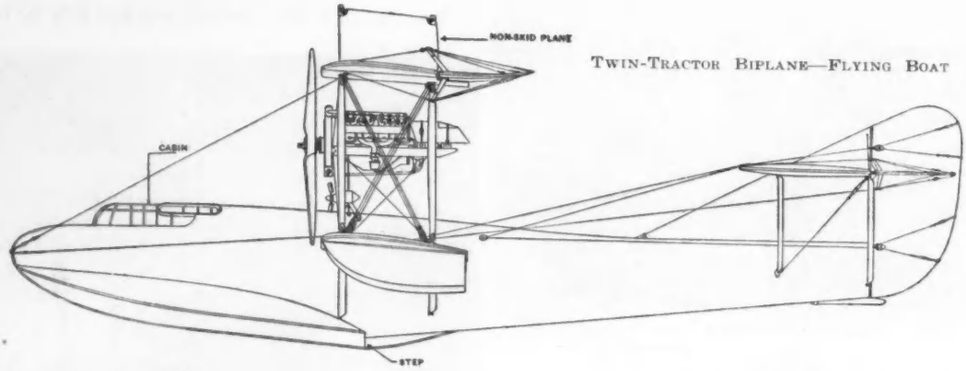
NOMENCLATURE OF AERONAUTICS

At this point it seems proper that we should, for the sake of clearness, consider some of the terms of aeronautic nomenclature in order that in the illustrations which follow we may discuss with freedom the character of the various models. For the sake of illustration I have used the standard training machine known as the JN-4D. This machine is a biplane of the tractor type, a two-seater, primary training machine equipped with a 90-hp. eight-cylinder aeronautical engine.

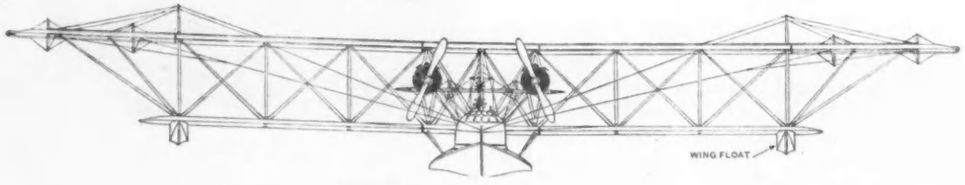
Facts About the Theory of Flight

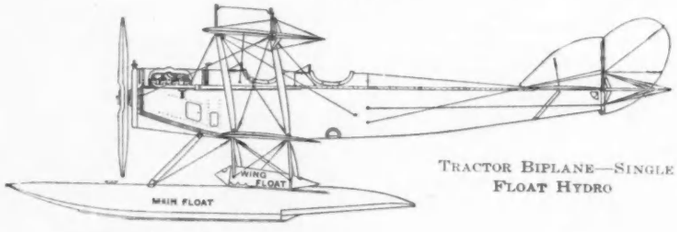
And now just a few words about the theory of flight. Many models and forms of airplanes have been studied, many experiments performed. The theory of flight is fairly well known, so that definite results can be predicted

GLENN H. CURTISS AT THE WHEEL OF ONE OF HIS FIRST BIPLANES

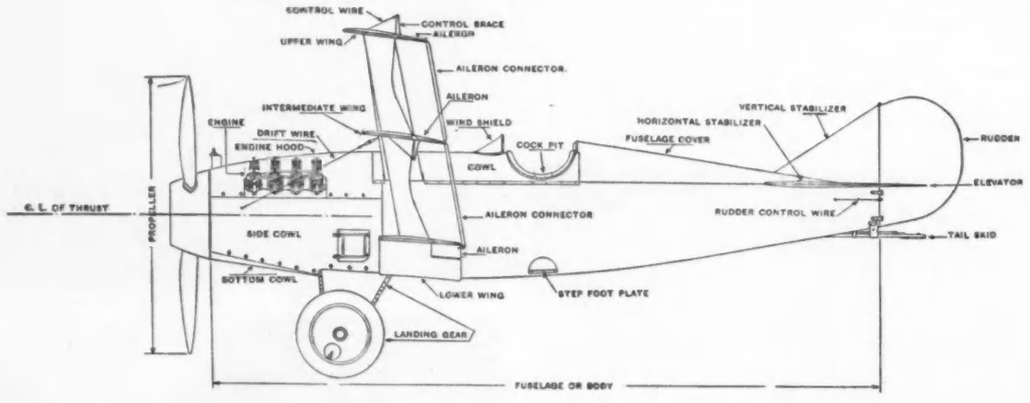


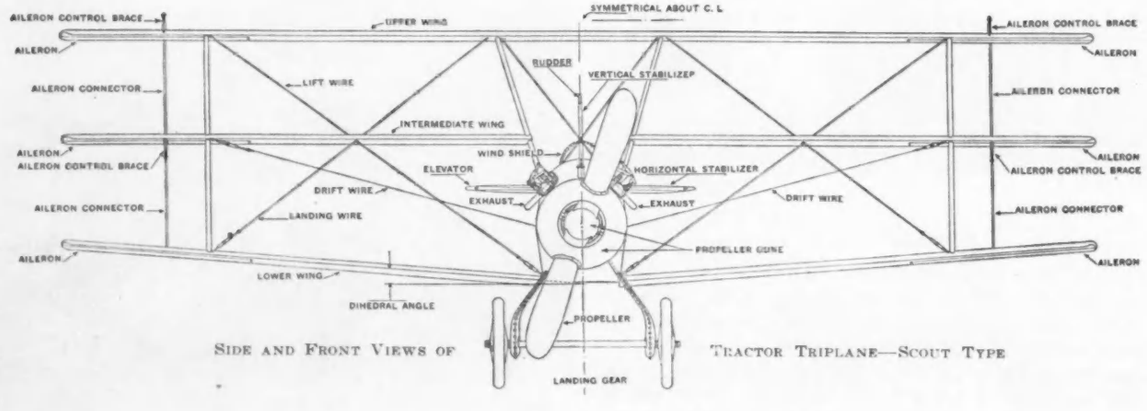
TWIN-TRACTOR BIPLANE—FLYING BOAT



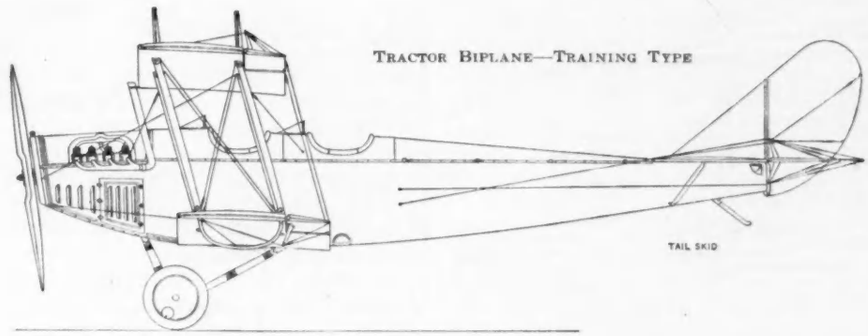


TRACTOR BIPLANE—SINGLE FLOAT HYDRO

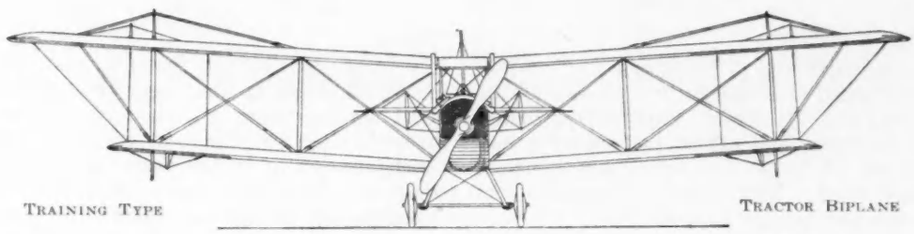




SIDE AND FRONT VIEWS OF TRACTOR TRIPLANE—SCOUT TYPE

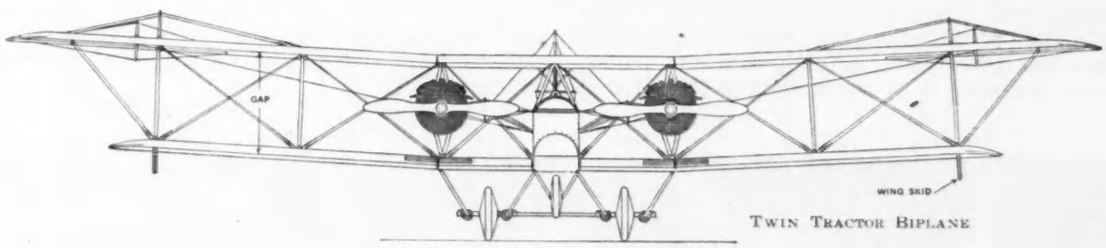


TRACTOR BIPLANE—TRAINING TYPE

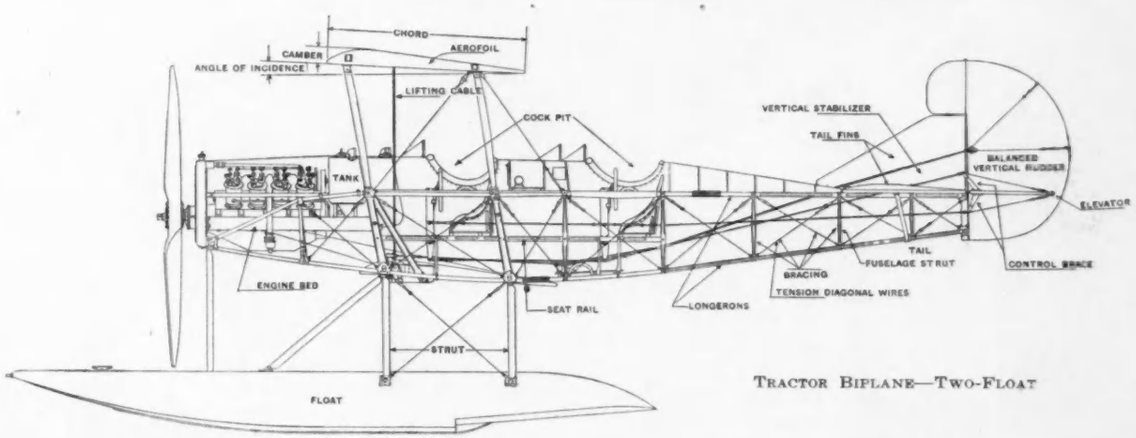


TRAINING TYPE

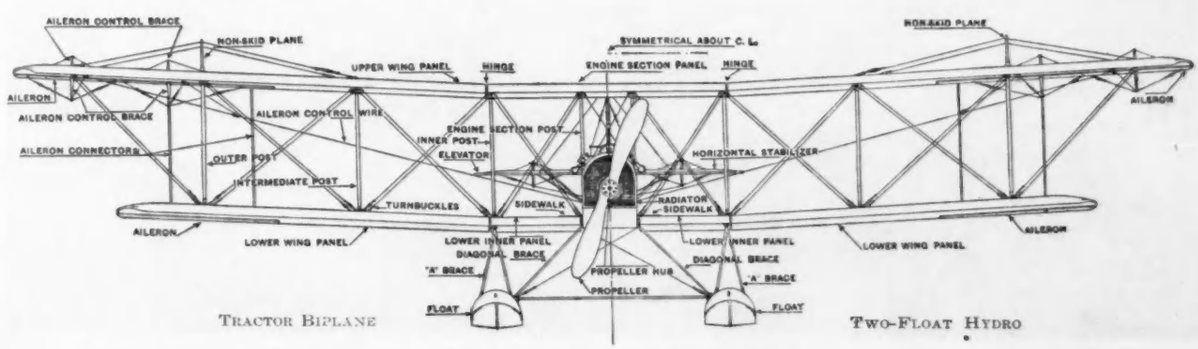
TRACTOR BIPLANE



TWIN TRACTOR BIPLANE

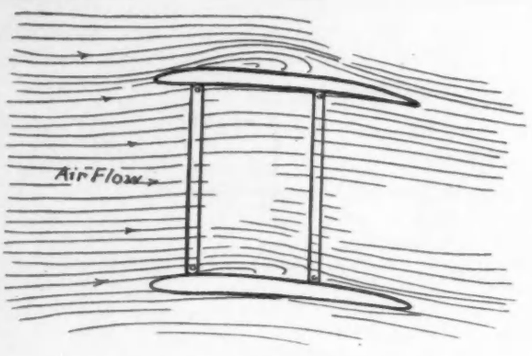


TRACTOR BIPLANE—TWO-FLOAT

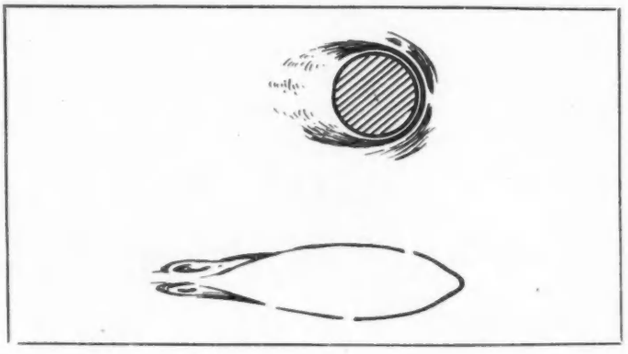


TRACTOR BIPLANE

TWO-FLOAT HYDRO



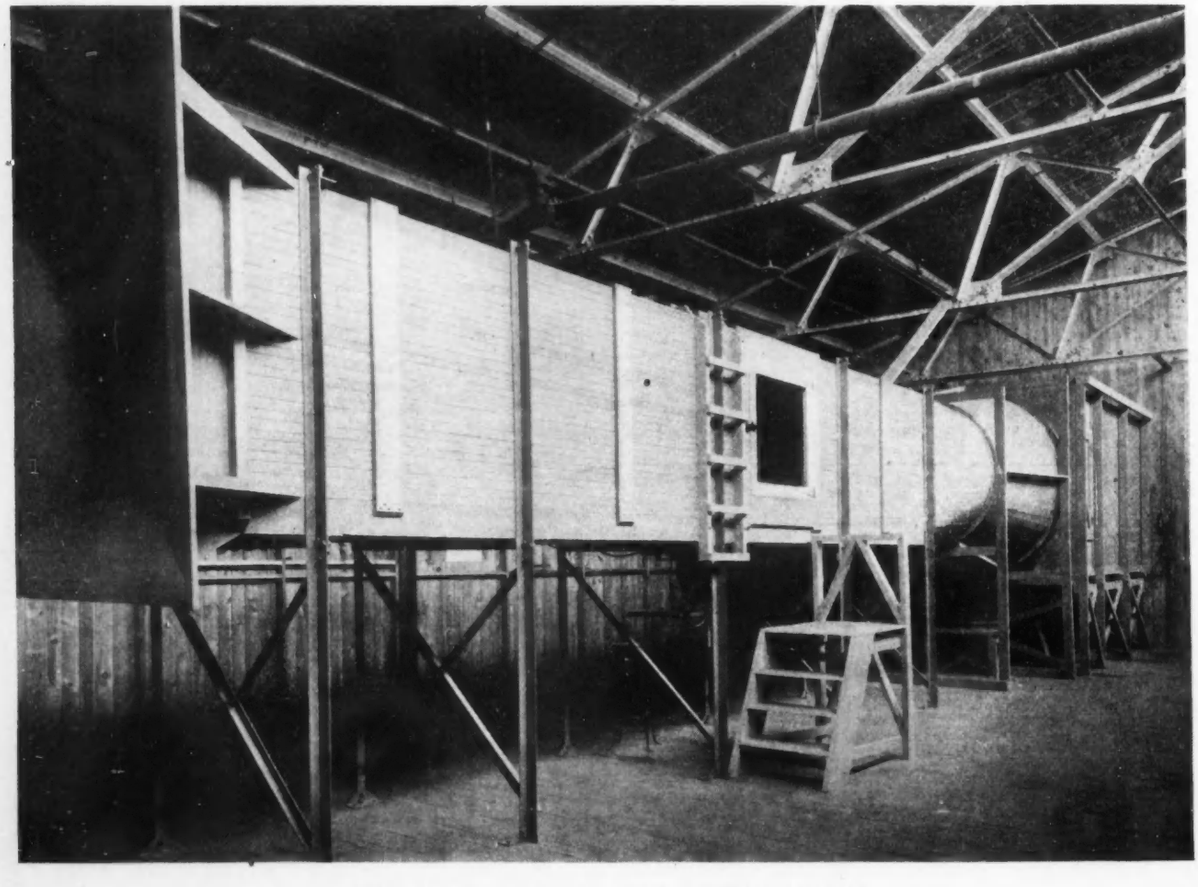
GRAPHICAL REPRESENTATION OF AIR FLOW



EFFECT OF STREAM LINING

from certain known conditions. Scientists and mathematicians have interested themselves in this branch of the engineering art, and M. Eiffel, Lanchester, Zahm, Hunsaker, Bryan, Bairstow and others have made many valuable contributions of facts upon which aeronautical design now securely rests. This scientific research has revealed many seemingly strange things.

Few people, for instance, know that about 66 per cent of the lifting force of the air is due to the suction on the upper surface of the wing panel, while only about 33 per cent can be credited to an actual pressure of the air on the under surface. It is also a significant fact that the force required to move a small wire through the air is as great as that required to move a stream-line strut several times its diameter. The influence of the stream-lining was formerly little understood and seldom taken account of in the design of struts, body and landing-gear. Scientific experimentation, however, revealed the necessity of cutting down head resistance, thus decreasing what is known as the "drag" or "drift." It indicated the necessity of changing the surfaces, the cross-section of the wing panels, the sections of the struts and other exposed surfaces, to forms which would offer less resistance.



WIND TUNNEL OF THE CURTISS RESEARCH DEPARTMENT

Effect of Stream-Lining

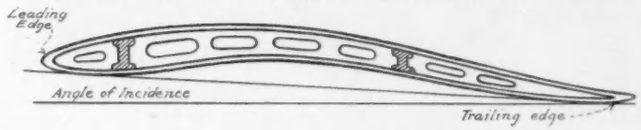
It is easy enough to push a thing into the air but it is hard to get it out without creating a disturbance. If we take a broomhandle, for instance, and sweep it through the air rapidly we find, if we could examine the air immediately following it, that a small vacuum is created just back of the stick itself, and that eddying occurs directly behind it, creating a V-shaped partial vacuum which decidedly increases the total power required to move the stick through the atmosphere. It was early found by experimenters that by filling up this vacuum, and changing slightly the entering surface, that the stick could be passed through the air much more easily; a considerably smaller amount of power would be required to move it.

Now, when we design an airplane we know before it goes up into the air almost exactly what it will do. We know, for instance that a certain type of wing-form has certain characteristics: one is good for weight carrying, another for speed, still another seems to combine successfully several desirable characteristics. Investigators have also discovered that what is known as an "end-wash" on a wing panel can be eliminated by cutting off the corner of the panel as indicated in the accompanying illustration.

Most American and Allied machines use that type of panel in which the end edges form an angle, the apex of which points to the front of the machine, but Bleriot has used a type of panel in which the angle formed by the end edges has its apex at the rear of the machine. This latter type of end section is known as the Bleriot end. Both types of panels have shown good performance.

The angle at which the wing panel meets the air is another subject of wide interest. The angle of incidence, for instance, which is the angle between the direction of flight and a tangent drawn through the lower surface of the wing panel, may be varied with interesting results.

Of course, the whole object of all this work is to decrease the "drag" and increase the "lift"—in other words, to secure a large "lift/drag," or efficiency ratio. Drag is always concomitant with lift, and is a measure of the waste energy that is spent in order to accomplish work. We cannot get lift without drag. Lift is a measure of the effective work, and drag is a corresponding measure



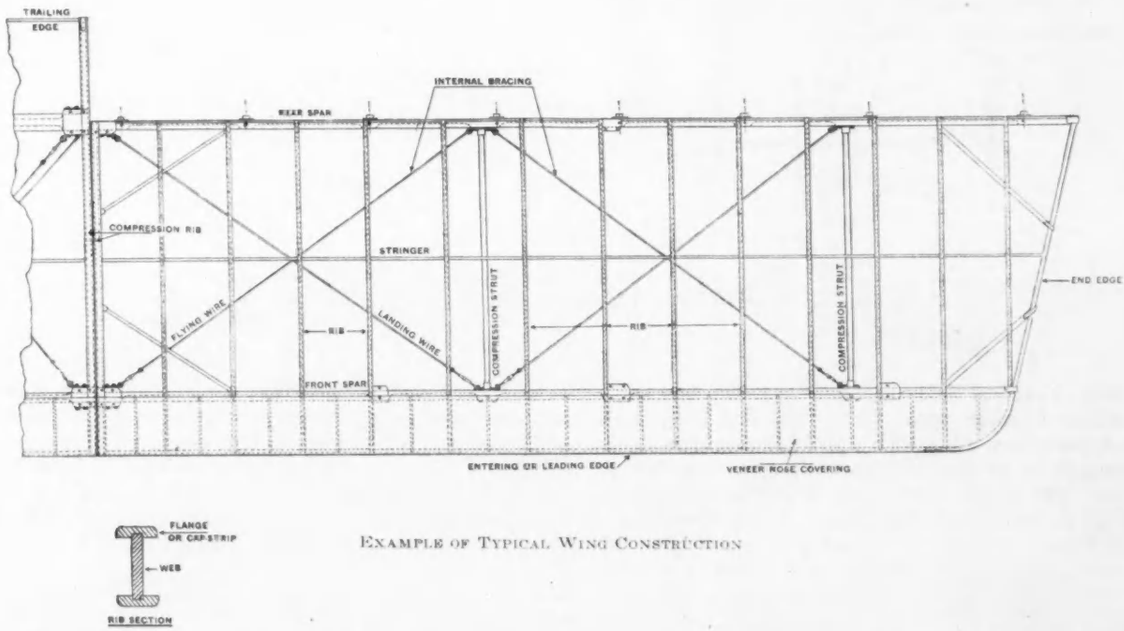
SHOWING A TYPICAL AEROFOIL SECTION

of the amount of work absorbed or lost and at the expense of which we get the lift.

A biplane, if the wings are not staggered, is about 82 per cent as efficient as a monoplane of the same total wing area. A triplane is about 60 per cent as efficient for the same wing area. Taken at an angle of 4 deg., the following are the parts of the load carried by the planes: Upper, 0.45; middle, 0.20; lower, 0.35. A monoplane has 1.22 as much lift as a biplane and 1 2 3 as much lift as a triplane. A biplane has 1.36 as much lift as a triplane. All of these ratios are on the basis of equal areas. The effect of stagger is to increase the efficiency of a biplane (relative to the monoplane) from 82 to 87 per cent, depending upon the stagger. For general purposes an aspect ratio of six is used. Fast racing machines usually have an aspect ratio of about six. For slower, weight-carrying machines, an aspect ratio of about seven or eight is used. The aspect ratio of the JN-4D is 7.3.

Some investigations made on dihedrals indicate that a considerable degree of lateral stability can be obtained by the same angle that would ordinarily be the result of sweeping back the wings. A somewhat superficial consideration of two or three wing sections may at this point be welcome, for instance:

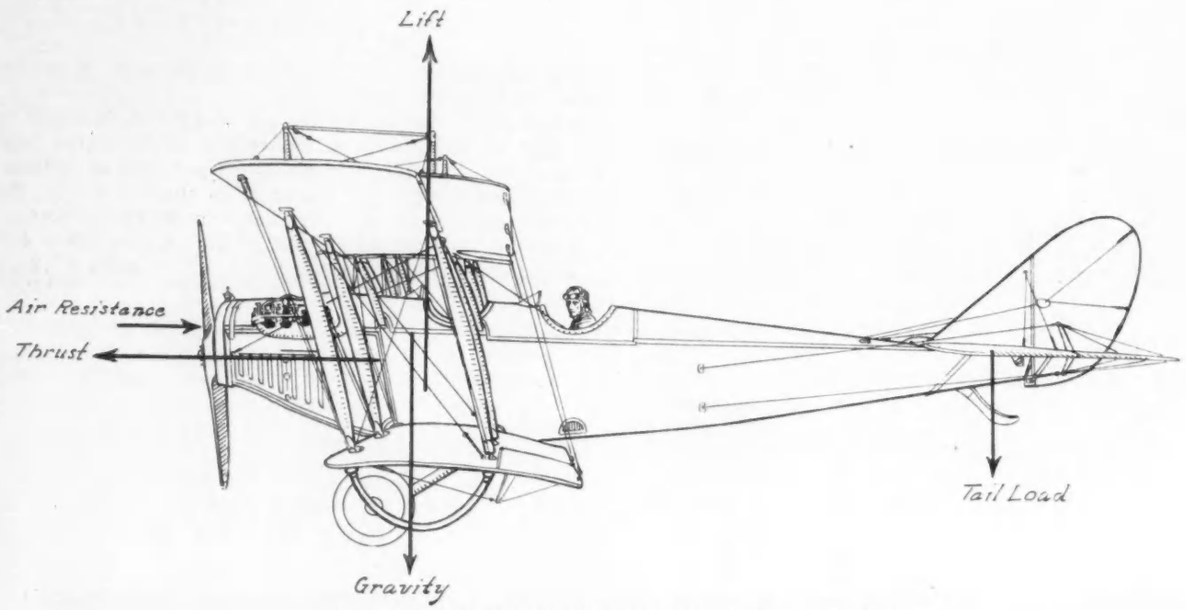
The R.A.F.-6 (upper curve), developed by the Royal Aircraft Factory under O'Gorman, has been found both by wind-tunnel prediction and by actual tests in the field, to be one of the best lifting cross sections at a fair rate of speed. It has a fairly large range of stability, which is desirable in a machine flying at a normal rate of speed and with a considerable load. It is



EXAMPLE OF TYPICAL WING CONSTRUCTION

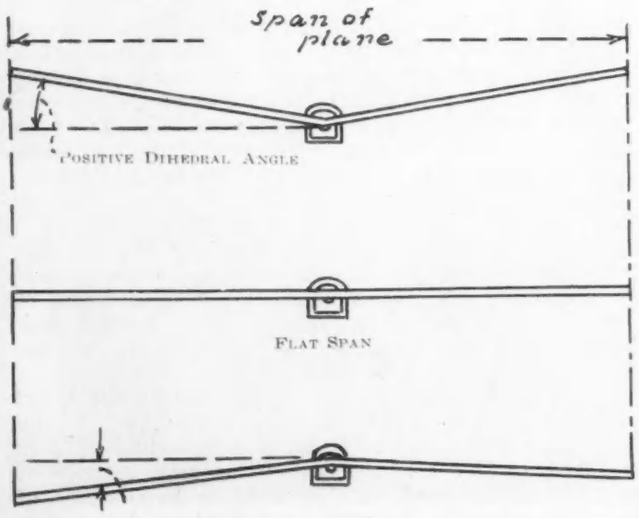
used in many of the heavier training machines. It is an excellent curve for hydro-work, inasmuch as a hydro-machine is generally heavier than a land machine for the same purpose.

The Eiffel 32 cross section is of a generally slender form, which gives a fair lifting capacity and also a considerably greater speed than the R.A.F.-6, with the same expenditure of power and carrying the same load; the reason being that this curve is somewhat better stream-lined. Of all the curves that Eiffel has developed, the Eiffel 36 is considered the best. While the lifting capacity at the same speed is not as great as that of an R.A.F.-6 curve, its resistance at the same speed is considerably less. Therefore, with the same power at our disposal we can actually pull this curve through the air at a greater speed, and hence obtain the same lift with lesser area. On account of this, it is a faster wing section than the R.A.F.-6.

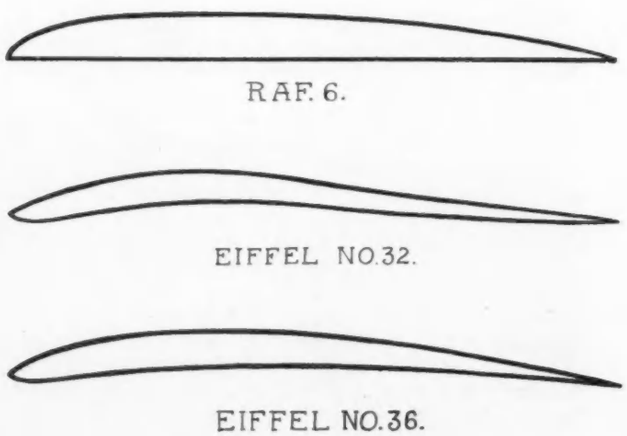


VIEW OF CURTISS-JN.4D—SHOWING ACTION OF PRINCIPAL FORCES

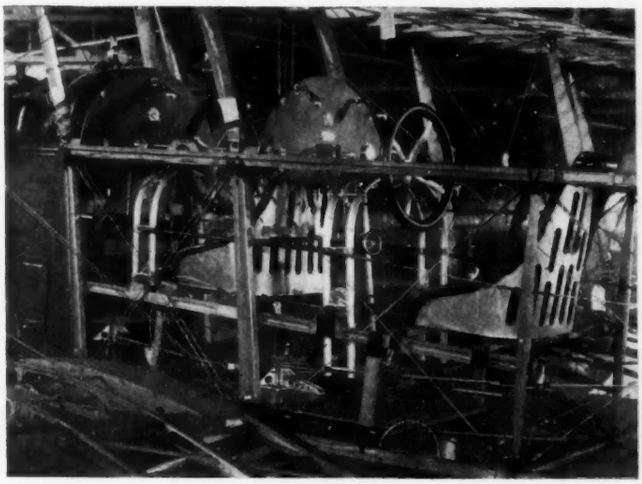
Scientists and the military authorities have developed and are today using curves that excel in all points of performance any of the three curves above mentioned. If the R.A.F.-6 curve, for instance, be said to have 15 as a factor of merit, and the Eiffel 36 be credited with a factor of merit of about 17½ to 18, we are using curves today whose factor of merit is about 22.



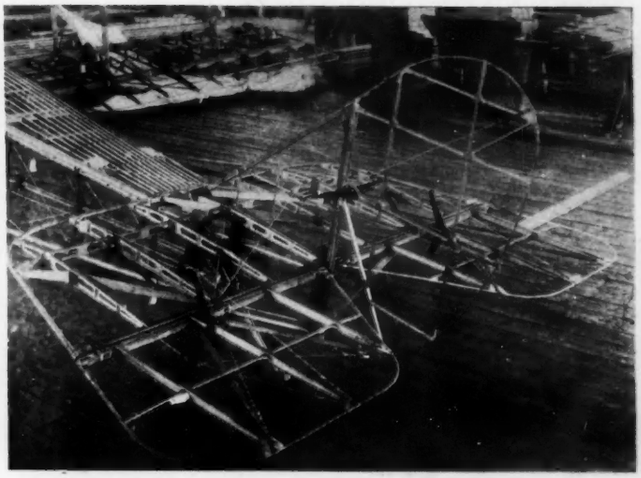
NEGATIVE DIHEDRAL ANGLE



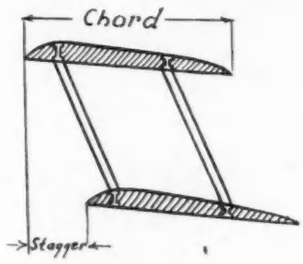
TYPES OF EFFICIENT WING SECTIONS

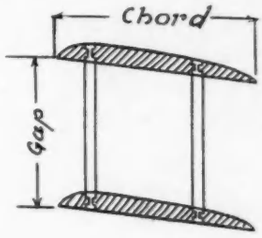


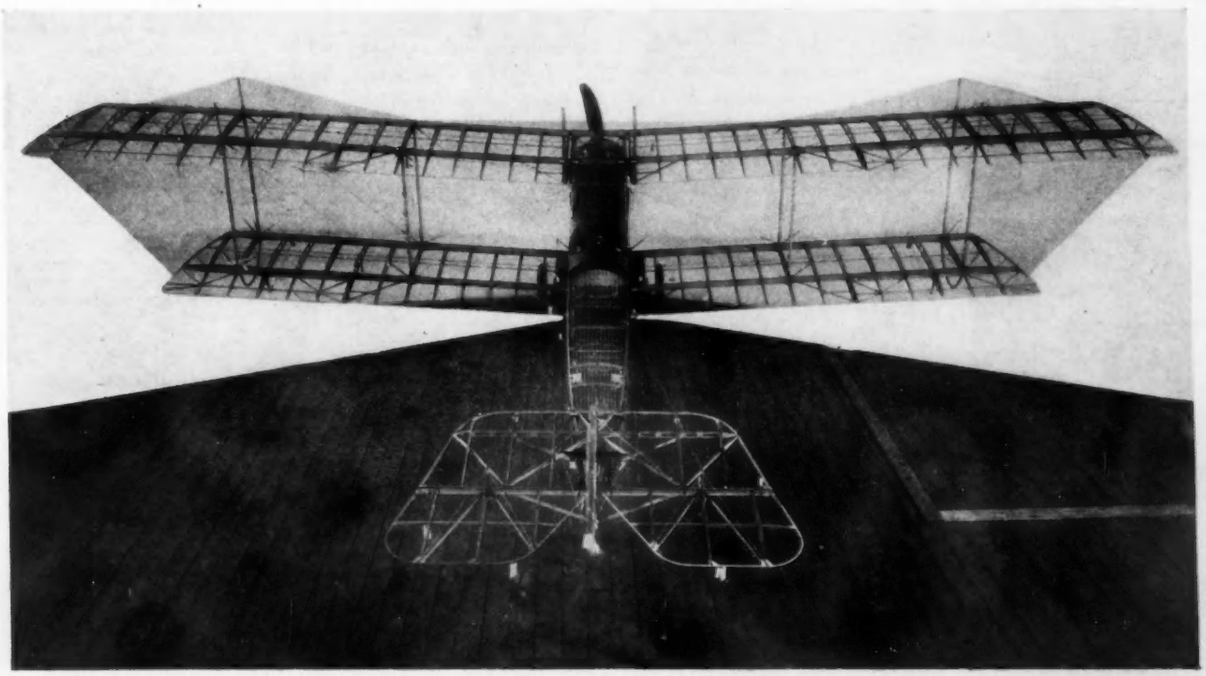
DEP OR WHEEL CONTROL



SKELETON VIEW OF THE EMPANNAGE







SKELETON VIEW OF A CURTISS JN4 PLANE

Classification of Machines

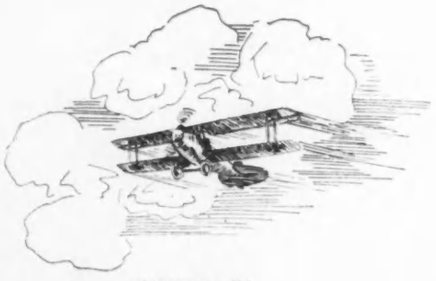
Modern airplanes may be divided into the following general types:

(1) *Combat Machines.* These are small, very fast, single-seater fighters, used for scouting purposes. They usually have a wing spread of from 20 to 25 feet, a speed of 125 to 135 m.p.h., carrying capacity of 450 lb., and a climbing speed of 10,000 ft. in from 8 to 12 minutes.

Nieuport (French) Fighter

Albatros D-1, Pursuit Plane

Single-seater, with continuous elevator over entire width. Rudder operates above elevator and is balanced. Has nearly all the



Albatros D1

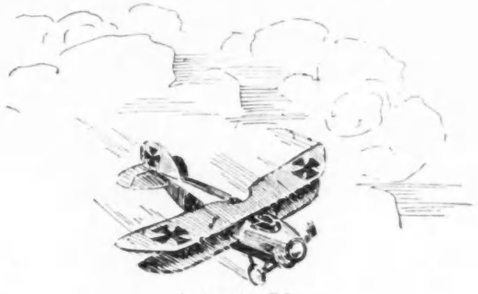
desirable features in airplane design. Stream-lining is very well done. Nieuport "V" type of strut copied. Climb not equal to that of the Spad.

The Spad, Nieuport, Morane, Curtiss-triplane, SE-5, Sopwith, Dolphin and German Albatros single-seater are examples of this type.

Combat Albatros D1 (German)

Albatros D-3, Modeled After the Nieuport

Single-seater scout equipped with a Mercedes engine. V-shaped struts and narrow lower plane. High vertical stabilizer and high rudder. Type of machine used in the famous flying circus, well



Albatros D3

known on the Front. Like the Nieuport it is easy to maneuver, but is not as fast or as good a climber as the Allied scouts. Elevator in one piece, balanced.

Bristol Tractor Monoplane

Small one-seater machine. Span, 30 ft. 9 in.; chord, 5 ft. 11 in. Overall length, 20 ft. 7 in.; height, 9 ft. 6 in. Driven by 110-hp. Clerget that uses about 6 gal. of fuel per hour. Air endurance, about 3 hours. Total flying weight, about 1320 lb., of which 410 lb. is useful load.

Front and Side Views of the Bristol Monoplane (English)

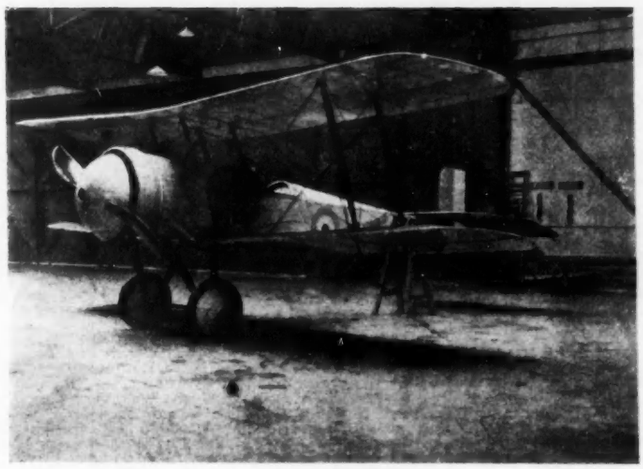
This machine requires a clever pilot to fly it, although it is comparatively easy to land. It is nose-heavy and has a tendency to turn to the right with the engine on. This model is credited with a speed of 128 m.p.h. at 5400 ft. and 110 m.p.h. at 15,000 ft. It will get off the ground in less than 100 yards, and can be stopped, with the engine off, in a little more than the same distance. It will climb about 16,000 ft. in 20 min.

To the eye it presents a pleasing appearance and offers a good example of stream-lined monoplane construction. The dihedral is 4 deg. and the tail plane has a small negative angle of incidence.

BRISTOL SCOUT MODEL D TRACTOR BIPLANE

Powered with an 80-hp., air-cooled Clerget, this one-seater is credited with a speed of about 95 m.p.h. It weighs about 1100 lb. and has a wing spread of 24 ft. 5 in. Length, 20 ft. 5 in.; height, 9 ft. 8 in. Its wings have a dihedral of 3 deg., angle of incidence of 2 deg., stagger of 1 ft. 4 in. Its aspect ratio is 5.5; chord, 4 ft. 6 in.; gap, 4 ft. 4 in.

The Bristol Scout is also equipped with 100 and 110 hp. Clerget engines. It is a very easy machine to fly, not at all tiresome, and lands easily. It will climb 10,000 ft. in 26½ min. Its weight is 1099 pounds.



BRISTOL SCOUT (ENGLISH) PLANE

D. F. W. AVIATIK C V

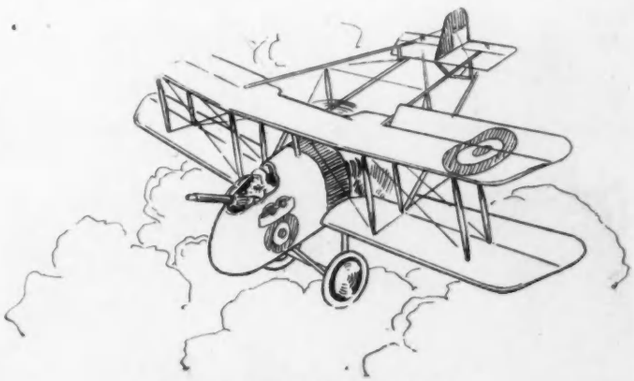
The wings have a dihedral but no sweep back. The span of the lower wings is 42 ft. 5 in., nearly equal to the span of the upper wings, which is 43 ft. 8 in. The ends of the upper planes are oblique, those of the lower retreating and rounded. The maximum chord is 5 ft. 9 in. The total lifting surface is about 421 sq. ft. The gap is 5 ft. 7 in. The angle of incidence of the upper plane is 5 deg. from the cabane to the sixth rib and 3.3 deg. at the thirteenth rib, where the ailerons commence. There are two pairs of struts on either side of the fuselage. The metallic ailerons are rectangular with rounded ends. The empennage has a heart-shaped appearance. The fuselage, rather shallow in depth, terminates in a vertical knife-edge in the rear, with a somewhat pointed propeller pot in front. It has the standard landing-gear.

The D. F. W. is equipped with a fixed Benz engine of 228 hp. at 1410 r.p.m., almost entirely enclosed in a special cowl. The radiators are mounted on the sides of the fuselage. The pilot sits on the gasoline tank, with a machine gun within easy reach of his right hand; the passenger sits behind in rear cockpit. The full load carried is 2100 lb., of which 660 lb. is the useful load.

AVIATIK D. F. W.

F. E.-8 (BRITISH) SCOUT TYPE SINGLE-SEATER PUSHER

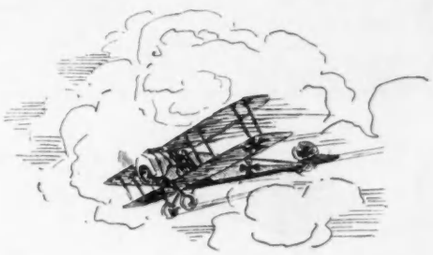
Equipped with rotary Gnome engine. Fin and rudder areas similarly disposed above and below tail planes. Four-bladed propeller. Lewis machine gun carried on deck of nacelle.



F. E. SCOUT OF PUSHER TYPE

FOKKER MONOPLANE WITH 100-HP. ROTARY OBERURSEL ENGINE

One of the first German machines to employ a mechanically-operated machine gun firing through the sweep of the propeller. Copy of the French Morane.



FOKKER

SMALL FOKKER TRIPLANE

Following closely the lines of the Curtiss and Sopwith triplanes, the Germans have recently put on the Front a small Fokker triplane which, like the originals of which it is a copy, shows an almost total absence of wires and lift bracing.

The planes have no dihedral but are staggered, and the two lower wings are slightly shorter than the upper one. The upper wing measures 22 ft. 2 in. and the lower 18 ft. 6½ in.; the overall length is 19 ft.

The machine is a single-seater, fighting scout, and armed with two fixed Spandau machine guns actuated by the engine.

It is powered by a rotary 100-hp. engine.

The fuselage is made up of steel tubes, hexagonal in form, ending with a vertical sternpost.

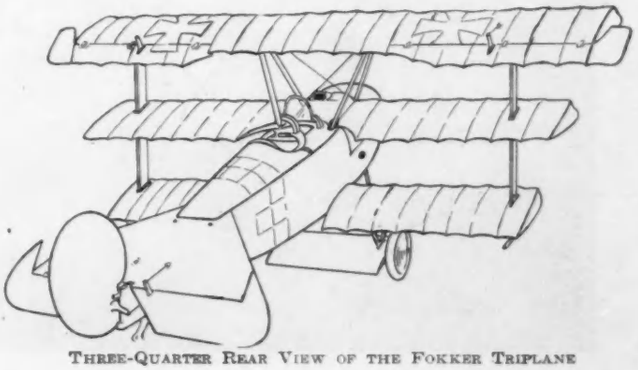
There is no vertical stabilizer, but there is a balanced Fokker type of circular rudder. The horizontal stabilizer is in the form of a triangle; the elevators are balanced, the empennage forming a large equilateral triangle.

The machine is plainly a copy of the Allied triplanes in use, and critics who have examined it have little praise for it.

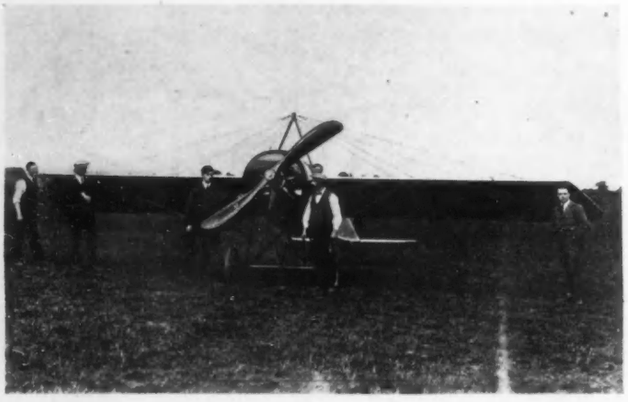
Its gross weight is about 1260 lb. and it will carry a load of about 430 pounds. Its loading is 6.14 lb. per sq. ft., and the weight per brake horsepower is 11.15 pounds.

When flying it has a heavy appearance and can easily be distinguished by the extensions of its balanced ailerons.

This is one of the first German machines to employ a mechanically operated machine-gun firing through the sweep of the propeller.



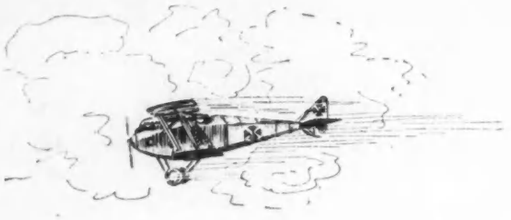
THREE-QUARTER REAR VIEW OF THE FOKKER TRIPLANE



MORANE (FRENCH) PARASOL

HALBERSTADT SINGLE-SEATER MACHINE

Equipped with an Argus or Mercedes engine. Fish-shaped fuselage. Staggered planes—the upper plane with overhang. Width, 28½ ft. and length, 24 feet.



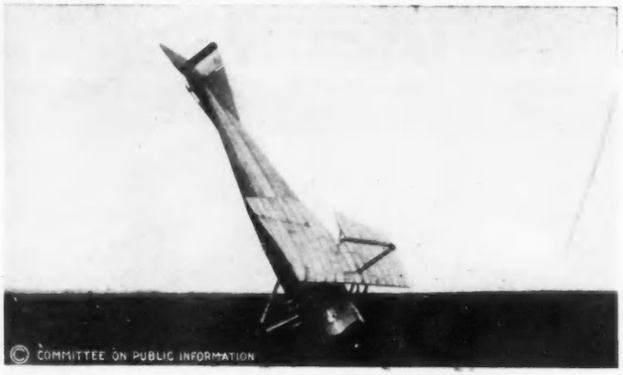
HALBERSTADT

MORANE PARASOL WITH 170-HP. GNOME ENGINE

This is the only monoplane now in use on the French Front, but on account of its good visibility and quick maneuvering ability, it is particularly well liked by many pilots. Span, 21 ft.; gross weight, 1400 lb., and useful load, 500 lb. Its maximum speed is 136 m.p.h. at sea level. It will climb 16,000 ft. in 16 minutes. It carries two machine-guns and gasoline for 1¾ hours. A jack-seat for the gunner is operated by a crank with which he can raise and lower himself. The plane is of steel construction (two-thirds of the fuselage). There are no wires; the bracing is of steel. It has a monocoque body, a pointed nose and small tail. It is light, speedy, sensitive and very trim.

MORANE THREE-PLACE TRACTOR

Two rotary Rhone engines or Hispano-Suiza engines. There are two pairs of vertical struts and two pairs of inclined struts on either side of the fuselage. The landing-gear is of a double M



MORANE PARASOL (FRENCH)

shape, and the machine is easily recognized by its fish-like fuselage. Its nacelles, in which the engines are carried, are mounted in V-shape supports. The upper wing has a slight overhang, no dihedral and no sweepback. The German A.E.G. and Gotha are very much like this machine and many of their features are copied from it.

The propeller is equipped with propeller-pot which aids in cutting down the head resistance of the machine. The planes are cut away for visibility. The elevators are of the balanced type.

The under-carriage structure has an M type of truss, and looks something like the Fokker and Halberstadt—which are German imitations of it.

TWIN-ENGINED MORANE—SAULNIER (FRENCH)

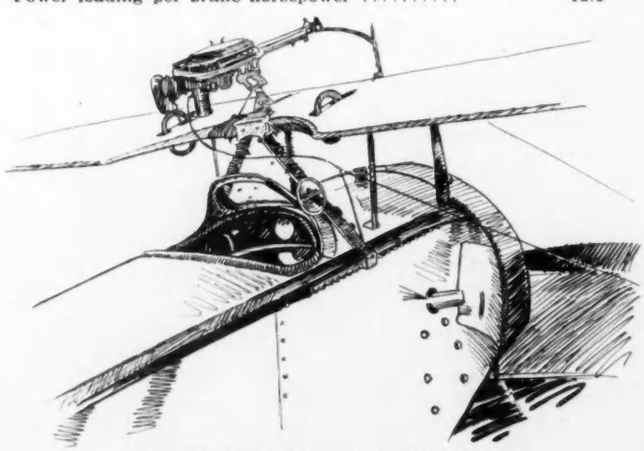
MORANE MONOPLANE (FRENCH) FROM THE REAR

NIEUPORT TRACTOR BIPLANE

One of the most important fighters of the French flying corps, combining speed and ease of handling with stability and short span.

One-seater tractor biplane, powered with a rotary engine. Two-seater machines are also built but not so widely used.

	Ft.	In.
Span, upper	24	8
Span, lower	24	3¼
Chord, upper	3	11
Chord, lower	2	5
Overall length	18	10
Height	8	1
Area, upper plane with ailerons	97 sq. ft.	
Area, ailerons	14 sq. ft.	
Stagger	2	3
Dihedral, upper	179 deg.	
Dihedral, lower	174 deg.	
Retreat	170 deg. 30′	
Incidence, upper	1 deg. 30′	
Incidence, lower	3 deg.	
Powerplant	80-hp. LeRhone	
Propeller diameter	8	2½
Climb	3,300 ft. in	4 mi.
	6,600 ft. in	7 mi.
	9,900 ft. in	11 mi.
	13,200 ft. in	16 mi.
	Lb.	
Gross weight	760	
Gasoline (20½ gal.)	121	
Oil (5 gal.)	44	
Useful load	451	
Total weight (loaded)	1210	
Lift loading per square foot	8.3	
Power loading per brake horsepower	12.1	



ARMAMENT OF NIEUPORT PURSUIT PLANE

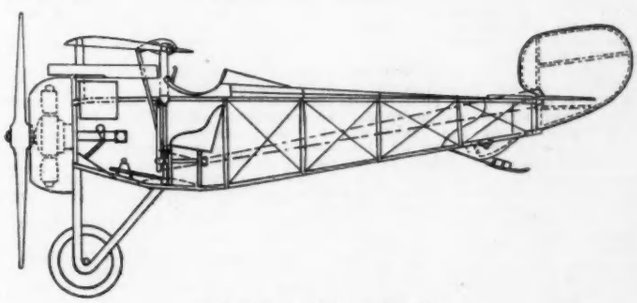
It has a single spar in the lower wing; V-type struts. The ailerons are mounted on a tubular shaft carried all across the wing and operated by pull and push rods instead of control cables.

The lower plane is mounted at a lesser angle of incidence than the upper plane. It carries one or two Lewis guns. If two, one is mounted on the upper plane, the other on the body in front of pilot. Both are stationary, and a synchronized device is provided for firing the lower gun through the propeller. The upper gun is prevented from doing this by an appropriate guide.

A number of different types of the Nieuport are made. Single-seaters usually have an 80 to 110-hp. LeRhone engine; the two-seaters have a 110-hp. Clerget.

The fuselage is a rectangular section girder, diagonally braced with wires; toward the rear the section becomes trapezoidal, as the bottom is narrower than the top. The stern terminates in a vertical rudder post. The top of the body is covered with a curved turtle-back covered with fabric. The fuselage fittings are of sheet steel with sockets for struts and lips for the bracing wires.

The main loads of the machine are concentrated in a narrow space near the front; the engine tanks and pilot's seat are close together.

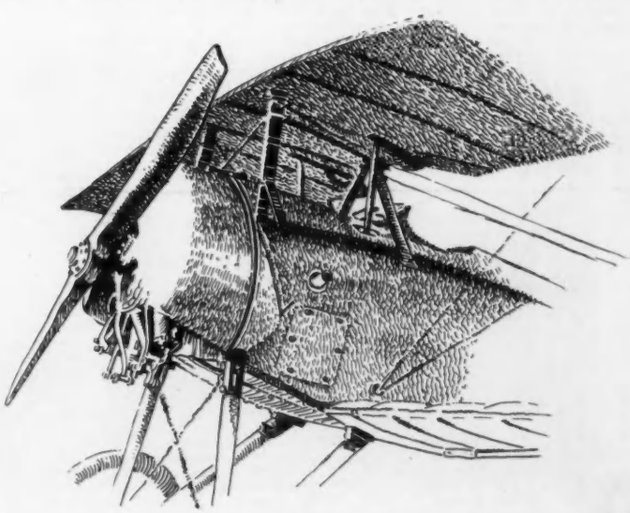


NIEUPORT MODEL NO. II

The engine is covered with an aluminum cowl. In some types it totally surrounds the engine; in others it is left open at the bottom.

The upper wings have two spars, while the lower, the chord of which is much smaller, have only one spar. The wings have a slight dihedral and backward slope. They are heavily staggered. The lower surface of the wings is nearly flat, while the upper surface is deeply cambered.

The angle of incidence may be changed by turning the lower wing on a bearing. Ailerons are controlled by tubes running through the wing panel, a system which makes for aileron efficiency.

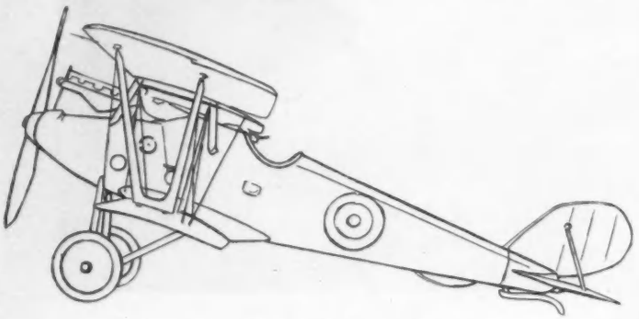


CLOSE UP OF NIEUPORT BIPLANE

PFALZ SINGLE-SEATER (GERMAN) COMBAT MACHINE

As a tribute to the Nieuport we find in this machine a strut construction similar to that of the famous French fighter, but differing slightly at the lower extremities. A good description is given in the April 18th issue of *Flight*, from which I quote:

"In outward appearance the Pfalz scout is chiefly remarkable on account of the fact that it imitates, as do the recent Albatros scouts, the wing bracing originated by the Nieuport firm, incorporating a larger top plane and a smaller lower plane. The type is frequently termed by the Germans a 'one-and-a-half plane.' The wing bracing differs, as regards the inter-plane struts, from that of the latter type Albatros single-seaters in that the lower ends of the struts do not meet at a point, but are connected by a short horizontal member. The lower plane has two spars according to usual practice, although these are placed rather close together, thus forming in reality a compromise between the single-spar lower plane of small chord and the ordinary two-spar lower plane with chord equal to that of the top plane.



PFALZ SINGLE-SEATER FIGHTER

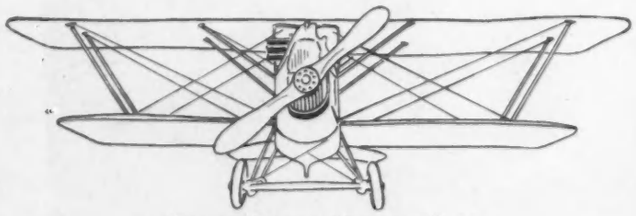
"The Pfalz follows Albatros practice in that the upper wing runs right through, and is in one piece. This construction is possible on account of the fact that no dihedral angle is given to the wings. The top plane is mounted on struts sloping outward from the body.

"The attachment of the lower wing to the body is interesting. Instead of the attachment usually found there is on the Pfalz scout a short wing root, built integrally with the body, to which the lower spars are secured. In order to attain this the three-ply covering of the body has a reflex curvature at this point, from the convex curve of the body to a concave curve, gradually merging into the shape of the wing section. There can be little doubt that this has been done in order to minimize resistance, but whether it achieves this purpose to any considerable degree may perhaps be open to doubt.

"The body of the Pfalz single-seater is of elliptical cross section and appears to be of comparatively good stream-line form. It is deep, so as to allow only just the top of the pilot's head to project outside, and to bring the top plane down low so as to obstruct the view to a lesser extent. It is narrow so as to allow the pilot a good view downward, the narrow overall width being rendered possible by the adoption of the semi-monocoque construction.

"Although being in general principle similar to the Albatros construction the body of the Pfalz differs somewhat in the manner of applying the ply-wood covering. Whereas that of the Albatros is put on in short rectangular sections, each covering only one span between adjacent body formers, the covering of the Pfalz is in the form of two thicknesses of three-ply, each in the form of long narrow strips put on diagonally, the strips of the inner skin and those of the outer running at approximately right angles to one another. It would appear that this form of construction is of some advantage, inasmuch as difficulty is always experienced in getting three-ply wood to bend to a double curvature. A sheet of three-ply may be readily bent along one axis, but even a very thin sheet will protest if one tries to bend it in addition along an axis at right angles to the former. The fact is, therefore, almost certainly at the bottom of the Pfalz construction.

"To the casual observer the tail planes of the Pfalz do not present anything of particular interest, but a closer examination reveals the fact that the tail plane appears to be put on 'the wrong way round.' That is to say, it has a flat top surface and a convex bottom surface. As far as is possible to judge from a somewhat hurried inspection, the tail plane is not set at any angle of incidence to the line of flight—either positive or negative—and one would therefore expect that during a steep dive the tail plane would exert a somewhat excessive righting force tending to 'flatten out' the machine abruptly. This is so unusual in a German machine, where frequently the tail plane is set at a positive angle of lift, as to give food for some speculation.



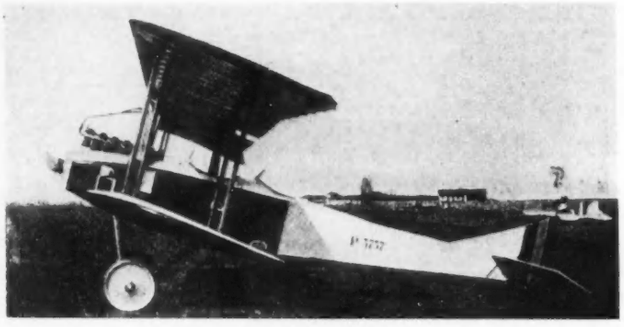
ITALIAN POMILIO FIGHTING SCOUT

"The engine fitted to the Pfalz scout, a 160-hp. Mercedes, is nearly covered in with the exception of the extreme top of the cylinder."

TWO-SEATER POMILIO WITH 6-CYLINDER, 200-HP. FIAT ENGINE

Is 38 ft. wide, 10 ft. high, 30 ft. long and will make 120 m.p.h.; climb 13,120 ft. in 22 minutes. Two sets of struts on either side of body. Double set of V-shaped struts from fuselage to upper plane. Very narrow but high cowl. Apparatus for release of bombs just below rear cockpit. Movable machine-gun mounted on a rotating ring in rear cockpit.

The ailerons on the upper plane increase in chord as they leave the trailing edge of the main plane. The trailing edges of the lifting and controlling surfaces are fluted. The upper part of the tail skid is enclosed in a stream-lined covering of sheet aluminum. The upper plane has no dihedral; the lower section has a slight dihedral angle.



POMILIO (ITALIAN) FIGHTER

ENGLISH S.E.5.A. SINGLE-SEATER FIGHTER

The two wings have an area of 22.8 sq. m.; span, 8.15 m., chord, 1.52 meters. Stagger, 0.46 m. The wings have no sweep back. Dihedral, 1°1 deg. The lower wings are cut away near the body for a better view. The angle of incidence of the wings is 5 deg.

The interplane bracing is stream-line wires. That of the overhanging portion is thick-ended wire. The trailing edge of the wings is formed by a wood strip. Between every two ribs are two short false ribs running from leading edge to front spar. The engine section struts are steel tubes stream-lined with wood fairings. The interplane struts are of wood. The lift wires are in duplicate and landing wires single. Non-balanced ailerons are hinged to the rear spar on both upper and lower wings.

The fuselage is a type of girder, and has a turtleback formed by vertical formers. It is covered up with wood as far as the pilot's seat. The tail plane, cambered on both sides, is so attached to body that its angle of incidence can be varied during flight from + 4.5 deg. to — 3 deg. The front spar oscillates freely from end; the rear spar and its bracing is attached to a tube, which can be raised or lowered in the stern post of the body.

The under-carriage is of the usual type. The tail skid, which is of unusual construction, is swivelled from the stern post and connected to the rudder control-cables. A brass shoe is sprung by means of two spiral springs enclosing telescopic tubes.

The enclosed Woiseley-Hispano engine develops 206 hp. at 2005 r.p.m.

The radiator forms the nose of the body. Shutters operated from the pilot's seat permit of covering up about half of the radiator. The main gasoline tank is mounted behind the engines on the upper longerons.

"CLOSE UP" OF A NIEUPORT (FRENCH)

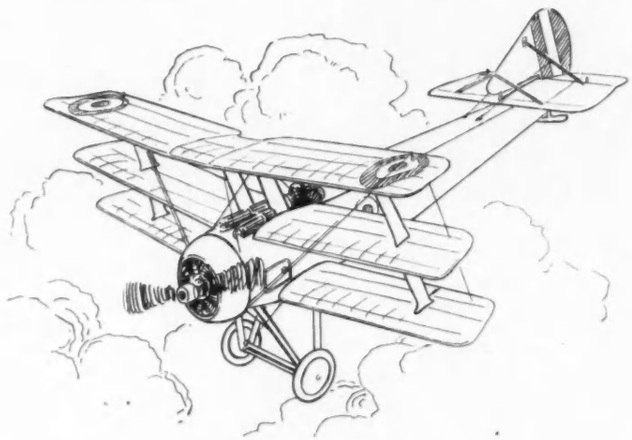
The fixed machine-gun is mounted to the left of the pilot inside the body covering. The firing of the gun is operated hydraulically by control mechanism in front of the engine, and driven by spur gearing on the propeller. The trigger is mounted on the control lever. On a bent rail above the center section of the upper plane is a Lewis machine-gun which can be pointed to fire upward during flight.

The weight of machine empty is 706 kg., and 250 kg. useful load is carried.

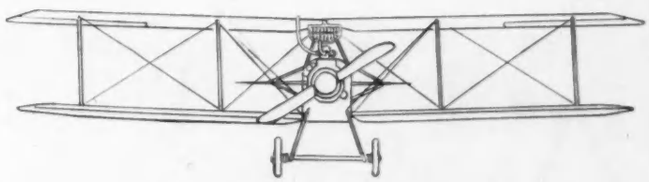
Sopwith Triplane for Scout Work

The Sopwith is unique among the new types of planes used in the war, as it is the first triplane that has found practical usage.

The chord is a little over 1 m., and the span 8 m. The employment of one strut on each side, with simple wing bracing, compensates somewhat for the increased wing resistance. The arrangement of the wings gives the pilot a better view, the middle wing being on a level with his eyes, the upper and lower with their small chord not interfering with the view as much as the wings of a small biplane with greater wing chord. The gap between the wings is 90 cm.; the stagger about 25 per cent. The wings are fitted with wing flaps connected by a vertical steel band. It carries in the nose of the body a 110-hp. Clerget engine in a circular cowl. The body is of rectangular section. The machine is built both as a single and two-seater with fixed gun in front above the fuselage; in the two-seater another gun is operated by the observer. The under-carriage has two V's of steel tubing with divided wheel axle, the hinge being braced by the fuselage.



Sopwith Triplane Scout



Front View of the Rumpler C-4 Type

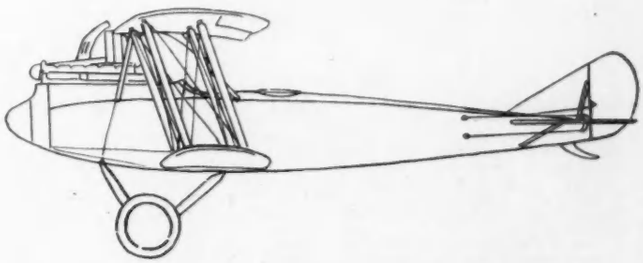
C-4 Rumpler (German) Single-Seater Biplane

The upper plane is 12.6 m. span, the length 8.4 m., height 3.25 m., chord 1.7 m., gap 1.85 m., dihedral angle 2 deg., the angle of incidence 5 deg. and a sweepback of 3 deg.

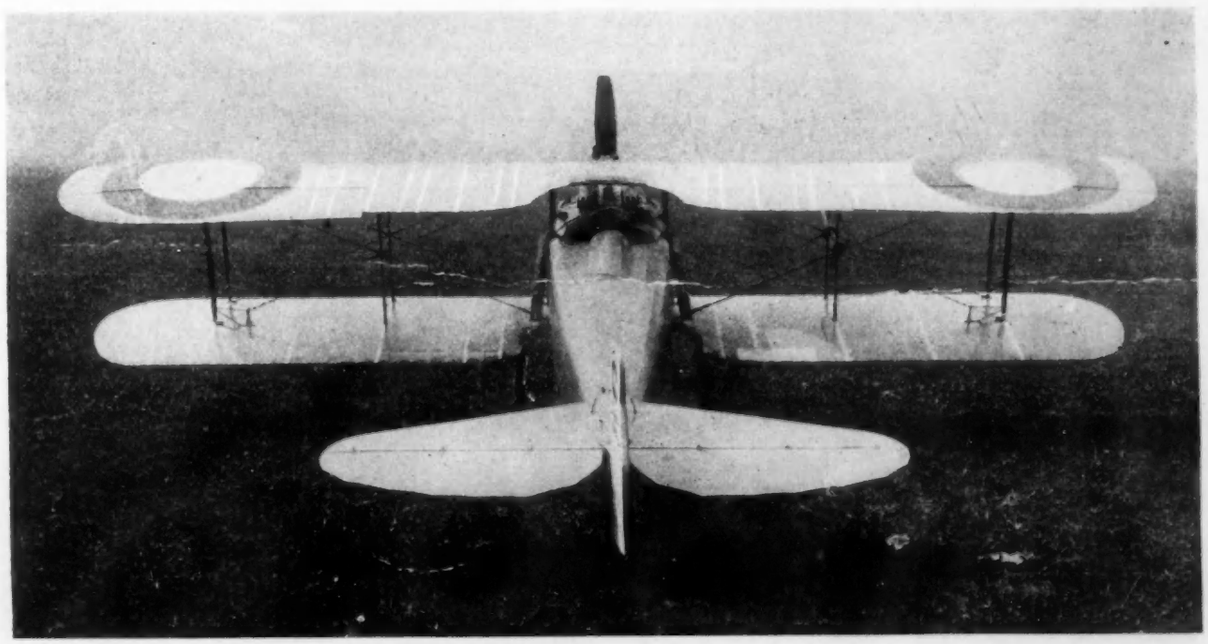
The C-4 is generally equipped with a 260-hp., six-cylinder Mercedes. The tank capacity is 290 liters. Contrary to German practice, the trailing edges are rigid.

The upper wings are cut out for visibility above the body. The lower wings have rounded tips like a D. F. W. It has two pairs of interplane struts on either side, narrow horizontal stabilizers and balanced elevators. The control cables are carried entirely within the body in wooden tubes. The fuselage is of regular construction of wood and wires. The engine is similar to that used in a Zeppelin; its radiator has blinds. It is equipped with one fixed Spandau machine gun. The pilot sits in front, the gunner in the rear. It has a Parabellum gun placed in the rear and four bombs, radio and camera are carried.

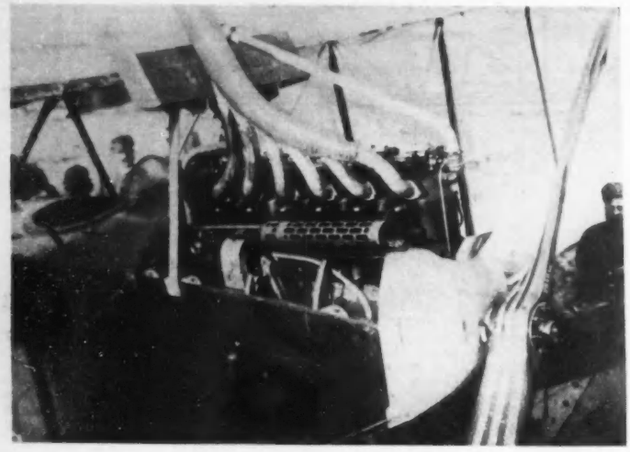
It will climb 16,400 ft. in 35 minutes. The machine is good for all purposes and high altitudes have been made with it. The machine can fly four hours.



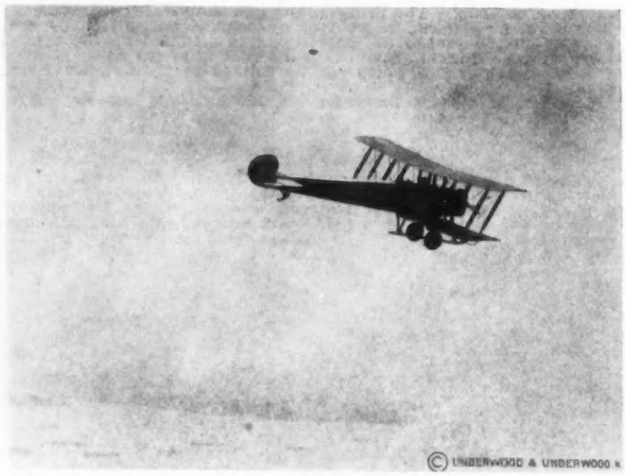
Profile of the Rumpler C-4 Type



Rear View of Spad Fighter (French)



CLOSE UP OF THE AVIATIK (GERMAN)



AVRO BIPLANE (ENGLISH)

SPAD FRENCH PURSUIT BIPLANE

The Spad is a single-seater, combat or pursuit biplane, with a 150 to 200-hp. Hispano-Suiza engine. It has a speed of from 120 to 130 m.p.h., and is an excellent example of good streamline design. The panels are of veneer construction, and the beams are made up of an I-beam section with two side pieces wrapped on with fabric. It is a remarkably good example of wood construction; veneer and aluminum being used in a wonderful manner. The fuselage is almost circular in cross section and is built up over a rectangle frame work. On four sides of this frame work are fastened circular segmental pieces over which the fabric is stretched. The tail units are not balanced. The French apparently do not like balanced units, but prefer a machine having the sensitiveness that unbalanced units give. It is said that they are much easier to maneuver in battle, can make turns and dive with greater facility. The Spad is so wonderfully made that even bad smashes do not seem to have much effect upon its structure. It has a 25-ft. spread and a 5-ft. chord. The chord is slightly greater than that of the Nieuport. The fuselage is very short. The machine is very light in construction—almost an engine with wings. The gross weight is 1500 lb., and it carries a useful load of 450 lb. It will climb 10,000 ft. in 9 minutes. Two years ago with 150-hp. engine it attained 118 m.p.h.; last year with a 200-hp. it reached 131 miles per hour. It is now being equipped with a 300-hp. engine, and a speed of 140 m.p.h. is expected.

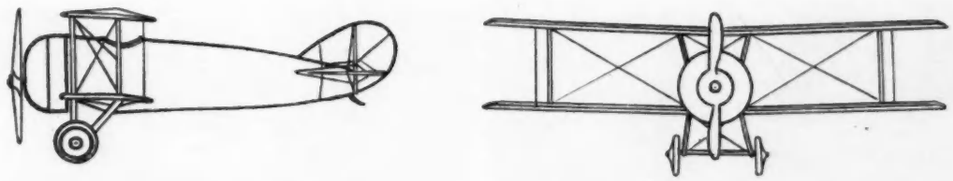
VICKERS SCOUT ES-1 ONE-SEATER BIPLANE

Rather chubby fuselage; small wing span, 24 ft. 4½ in.; only 20 ft. 4 in. long and 8 ft. 10 in. high. Driven by 100 to 110-hp. air-cooled Clerget, or 110-hp. LeRhone, equipped with 8-ft. 6½-in. propeller of 8-ft. 2½-in pitch, two-bladed. Aspect ratio 5.1. Small dihedral of 1 deg.; no stagger and no angle of incidence. Chord, 4 ft. 9 in.; gap, 4 ft. Total weight, 1500 lb. Carries 28 gal. of gasoline and 6½ gal. of oil. Climbs 10,000 ft. in 18 min. Maximum speed, 112 m.p.h.

The Vickers Scout is a difficult machine to fly and tiring on the pilot. Great care is required in landing. The machine is tail-heavy with the engine on. It will get off in about 325 ft. and can be stopped in 600 ft. if the engine is off. A slightly better performance is attained by the use of the 110-hp. LeRhone engine.

Completely surrounded by aluminum cowl. Slender pair of struts on either side of the body, pronounced stagger. Upper and lower planes have equal span. Three small struts from fuselage to upper wing. Very wide empennage, almost a parallelogram.

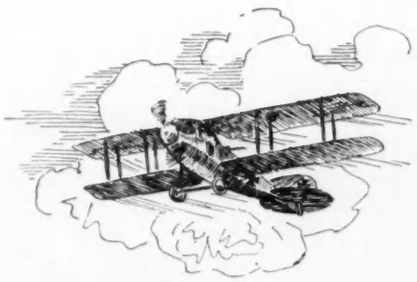
AN ENGINE WITH WINGS—THE SPAD FIGHTER (FRENCH)



VICKERS SCOUT E.S.1 WITH ROTARY ENGINE

C. V. ALBATROS BIPLANE (GERMAN) TWO-PLACE FIGHTER

Distinguished easily by its peculiar empennage construction and shape, this fighter presents several interesting points of construction. It has a well stream-lined fuselage which terminates in a horizontal knife-edge at the tail and supports two large segmental horizontal fins and a full-width balanced elevator above which is mounted the vertical fin and rudder.



ALBATROS C. V.

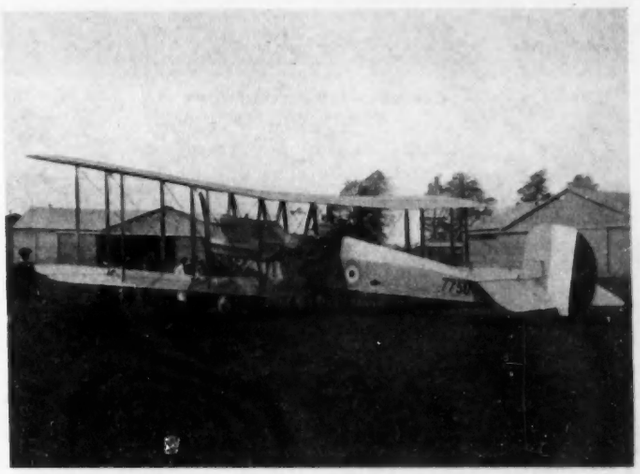
The span is 42 ft. for upper wing and 40 ft. 6 in. for the lower wing. It is 30 ft. long and has a wing area of 440 sq. ft.

A very complete description of its construction and a large number of detailed drawings to scale are being published in *Flight*, the well-known English aeronautical paper.

BRISTOL WITH TWO 120-HP. BEARDMORE ENGINES

Two two-bladed propellers of 9 ft. 6 in. diameter and 7 ft. 8½ in. pitch. Weight, 5210 lb. Maximum speed, 85 m.p.h. Comparatively wide span of 53 ft. 6 in.; overall length, 39 ft. 2 in., and is 12 ft. 8 in. high. Capacity for 115 gal. of gasoline, 9 gal. of oil, and 10 gal. of water. Total wing area, including tail planes and elevators, 945 sq. ft., making a loading of 5.5 lb. per sq. ft. Aspect ratio, 6.7. Stagger slightly less than 1 ft. Dihedral, 4 deg.; angle of incidence, 2 deg.; chord, 8 ft.; gap, 7 ft. 10½ in.

This machine is heavy and extremely trying to fly. It has to cover considerable ground to get off and cannot be landed in a small field. It is a very slow climber, taking 54 min. to climb 10,000 ft.



TWIN ENGINED BRISTOL (ENGLISH)

BODY CONSTRUCTION OF SPAD FIGHTER (FRENCH)

CAPTURED L.V.G. (GERMAN)

HEAD-ON VIEW OF THE L. V. G. (GERMAN)

L.V.G. (MADE IN TWO TYPES)

The D-9 has a 175-hp. Mercedes or Benz engine, the D-2 a 235-hp. engine. It is distinguished by its half-negatived ailerons. The D-2 has a wing chord greater near the fuselage than at its extremities.

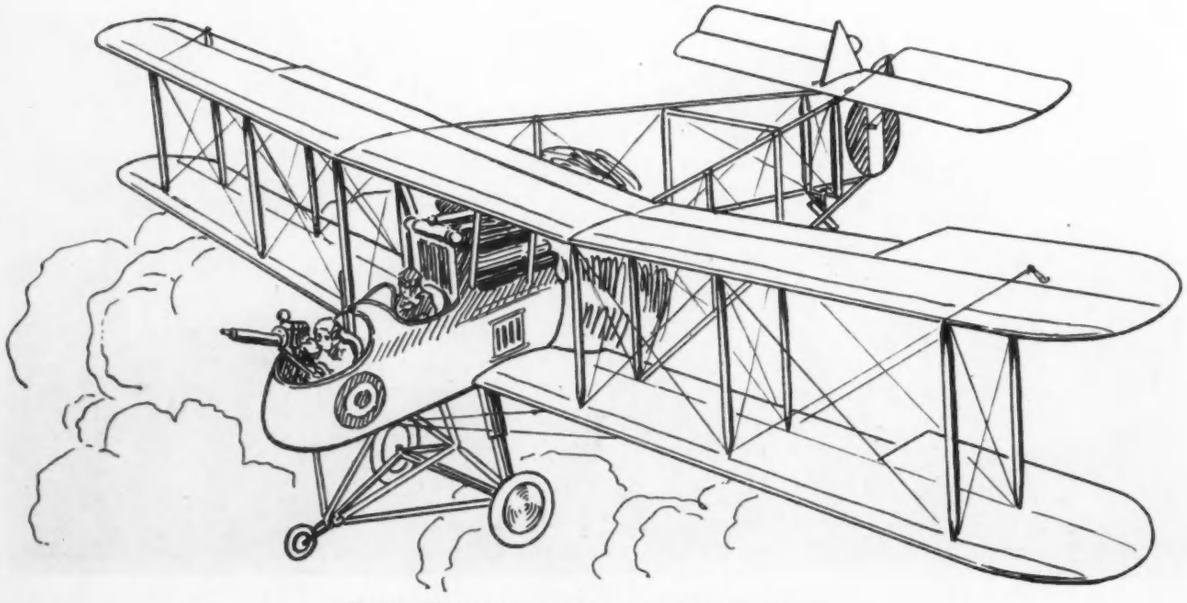
TWO VIEWS OF THE LIBERTY DH4 (AMERICAN)

ENGLISH DH4 (REDESIGNED TO TAKE THE LIBERTY ENGINE)

This machine has a wing-spread of 42 ft. 7 in. Its length over all is 30 ft. 7 in. It is equipped with one Liberty twelve 420-hp. engine. Its weight, empty, is 2337 lb., and when completely loaded about 4100 pounds.

F. E.-2B AND 2D PUSHER TYPE OF MACHINE

Nacelle carries a Beardsmore or Rolls-Royce engine. Empennage carried on four outriggers. Landing-gear consists of two main wheels, with two small auxiliary wheels forward.



BRITISH F. E.-2D WITH GUNNER IN NOSE OF FUSELAGE

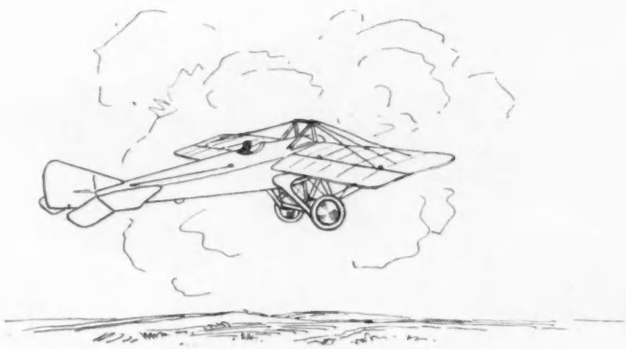
FE-2B (English) Pusher Plane

Squadron of FE-2B (English)

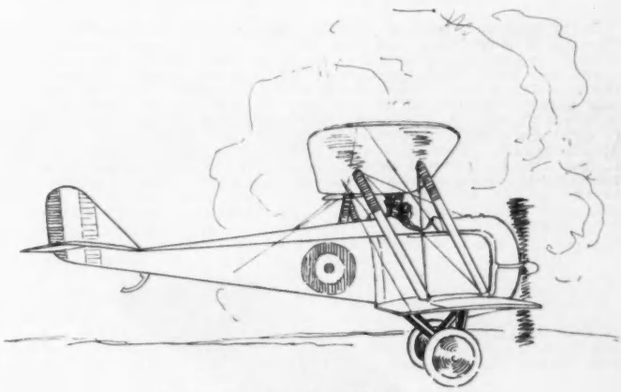
Morane Saulnier Two-Seater Tractor Biplane

Equipped with 110-hp. LeRhone engine. Wing span, 28 ft. 2 in. Overall length, 22 ft. 9 in., and is 9 ft. 4 in. high. Aspect ratio is 5.3. No dihedral, but reverse stagger of 4 in. Chord, 5 ft. 3½ in., and gap, 4 ft. 6 in. The total weight is 1667 lb. and the weight divided by horsepower equals 15.2.

It is unstable in all directions, but easy to fly. It has no fixed tail surface and therefore is not so safe to land. It is credited with a speed of 83 m.p.h. at 10,000 ft., and climbs 10,000 ft. in 27 min.



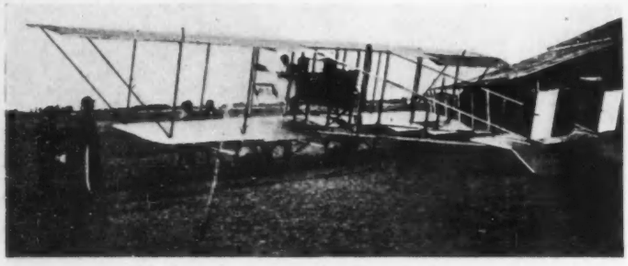
Deperdussin Racing Monoplane



De Haviland Plane (English)

Battleplane (DH4) Built in United States

(2) *Reconnaissance and Photograph Machines.* These are a slower flying machine intended for reconnaissance and photographic work. They are used for artillery spotting, map making and general reconnoitering. The wing spread is usually from 40 to 60 ft., and the speed from 80 to 100 m.p.h., the carrying capacity from 800



FARMAN (ENGLISH) RECONNAISSANCE

to 900 lb., the machines being two or three seaters, and having a climbing speed of 10,000 ft. in 12 to 25 minutes. Examples of this class are: De Haviland, Bristol, Curtiss, Voisin and Farman.

BREGUET RECONNAISSANCE TWO-SEATER

It is powered with a 450-hp. Renault twelve-cylinder engine. The gross weight is about 3700 lb. It carries a live load of about a half ton. It has a spread of 38 ft., a small dihedral on the upper plane only and a little sweep back. It is made largely of aluminum. the ribs are wood. The speed is about 128 m.p.h., and the machine will climb 16,000 ft. in 19 minutes. It carries four machine guns. It has a double set of ailerons, the lower ones being longer and extending from the wing tip nearly to the body. The elevators are balanced. There are two vertical fins and a vertical rudder. It has a three-wheeled landing-gear. The machine may be recognized by its three sets of struts on either side and set of V-struts in the center, the line of which if continued makes a large V with the front landing-gear. An M is formed by the trussing of landing-gear.

BREGUET IN FLIGHT (FRENCH)

BRISTOL TWO-SEATER TRACTOR BIPLANE

One of the best known of British reconnaissance machines. Powered with a 200-hp. water-cooled engine, driving a four-bladed propeller of 8 ft. 1 in. diameter. Credited with air speed of 111 m.p.h. At this speed it consumes 14½ gal. of gasoline with the engine running at 1290 r.p.m. Equipped with this engine it climbs at the rate of about 68 m.p.h. Wing spread, 42 ft. 6 in. Overall length, 31 ft. 1 in.; 10 ft. high. Aspect ratio, 7.7. Dihedral, 3 deg.; stagger, 12 in.

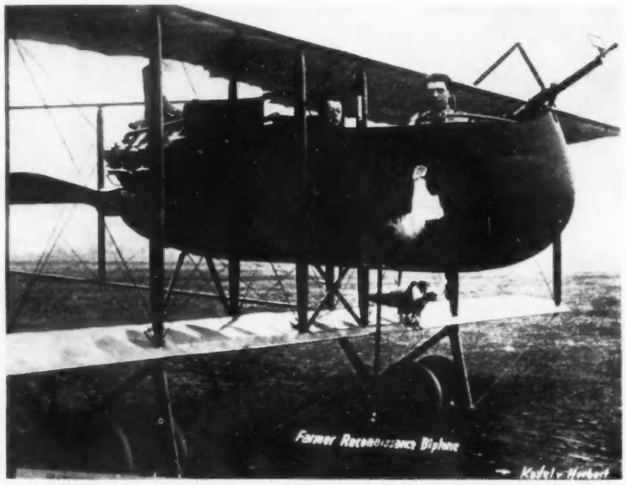
Equipped with a 310-hp. Rolls-Royce and crew of two, this machine carries a total military load of 545 lb., makes a speed of 130 m.p.h. at 10,000 ft., and climbs 15,000 ft. in 21 min. It has an air endurance of four hours at full speed at 15,000 ft., including climb to that height. The machine weighs fully loaded 3575 lb. The machine is modern in design and has a tail that can be adjusted by the pilot so that he is enabled to climb at any speed without effort.

F.E.-2B (ENGLISH) BIPLANE

BRITISH F.E-2B TWO-SEATER PUSHER BIPLANE

Equipped with 160-hp. Beardmore and four-bladed propeller 8 ft. 11.9 in. diameter. Wing spread, 48 ft. Chord, 5 ft. 6 in. Gap, 6 ft. 3 in. It is 33 ft. 4 in. long and 12 ft. 8 in. high. Carries total useful load of 976 lb. Total flying weight is 3037 lb. The best climb with which it is credited is 10,000 ft. in about 40 min.

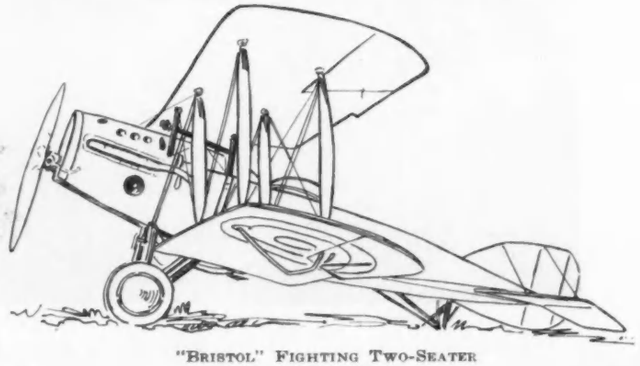
It is very stable and is especially useful for photographic and reconnaissance work. Being a pusher the engine is located in the after part of a nacelle, and the empennage is carried at the extremity of a V-shaped outrigger system of trusses. The machine has a wide tail with a comparatively small chord. The nacelle projects forward from the central portion of the machine and carries a pilot in the after cockpit and a gun and gunner in the forward. The landing-gear has the well-known third wheel in front. The machine is readily distinguishable on account of its peculiar rudder form.



FARMAN (ENGLISH) PUSHER TYPE

FARMAN F-40, SINGLE AILERONS ON UPPER PLANE ONLY

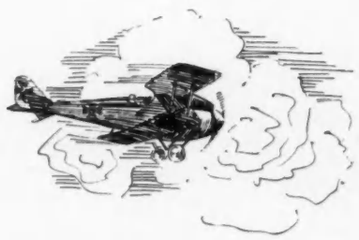
Pusher type of biplane with a Renault or Lorraine-Dietrich engine. Nacelle above the lower wing plane which has only about two-thirds the span of the upper panel. Empennage carried at end of outriggers, which terminate in vertical knife-edge.



"BRISTOL" FIGHTING TWO-SEATER

ROLAND (GERMAN) TWO-SEATER WITH 175-HP. MERCEDES

Carries machine gun and bombs. Fuselage egg-shaped, very high and narrow. Windows provided in sides of fuselage for observation. Fuselage fills in entire space between wings. Only one interplane strut on either side of fuselage. Planes considerably staggered. Fin and rudder very high.



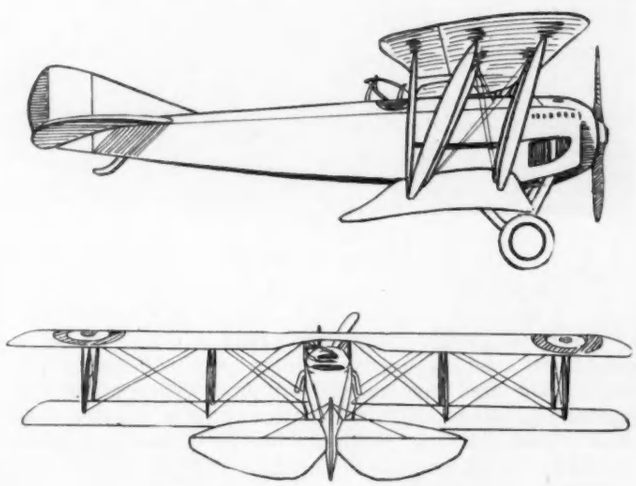
ROLAND D.II

GERMAN RUMPLER TWO-SEATER MACHINE

It is equipped with a 260-hp. six-cylinder vertical engine, but actually develops 286 hp. at 1500 revolutions. It has little dihedral and very little stagger. The war load is 1150 lb., and it will attain

RUMPLER

a speed of 110 miles per hour. It cannot climb very well, making only 14,000 ft. in 35 min., and 16,000 ft. in 43 minutes. Its weight is 10.6 lb. per square foot.



SIDE AND BACK VIEWS OF TWO-SEATER SPAD

S. I. A. TWO-PLACE COMBAT MACHINE

This Italian biplane has remarkable air endurance. It made a non-stop flight from Turin to London and a 1000-mile flight from Turin to Naples and return. It is equipped with a six-cylinder Fiat engine with an exhaust stack leading to the upper plane. Both planes have an equal span. Central braces from the fuselage to the upper plane are in the form of a letter W. The trailing edges of plane surfaces are straight and not formed of wire. A balanced rudder is used. It has a high forward compartment and flies in a tail-high position so that the pilot-seat is unobstructed.

S.I.A. (ITALIAN) WITH 300-HP. FIAT ENGINE

SPAD TWO-SEATER MACHINE

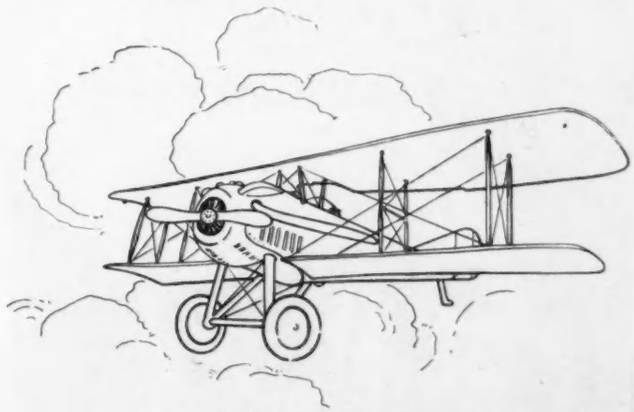
The Spad two-seater differs from the single-seater in that the divided inner interplane struts usually found on latter are omitted. It is built as an ordinary two-strutter. The upper wing span is 11.22 m.; the chord, 1.53 m.; lower wing span, 10.90 m., and chord, 1.43 m. The gap is 1.335 m., and the stagger 0.4 meter. There is no dihedral angle. Both wings sweep back at an angle of 174 deg.

For better view the lower wings are cut away near the body and the upper wing has a portion cut out in the center. The angle of incidence of the upper plane is 2.8 in center and 2.5 deg. at tip. The lower plane has a uniform angle of 1.5 deg.

The lift wires are in duplicate. The space between is filled up with wood strips to reduce head resistance. It has non-balanced ailerons, hinged to false spars in upper plane, and operated by pull and push rods resting in lower plane behind the rear spars.

The stabilizing and control surfaces are of the usual Spad type. The body, which is of the usual construction with four longerons, is rounded off top and bottom by formers and stringers. The machine is provided with dual control.

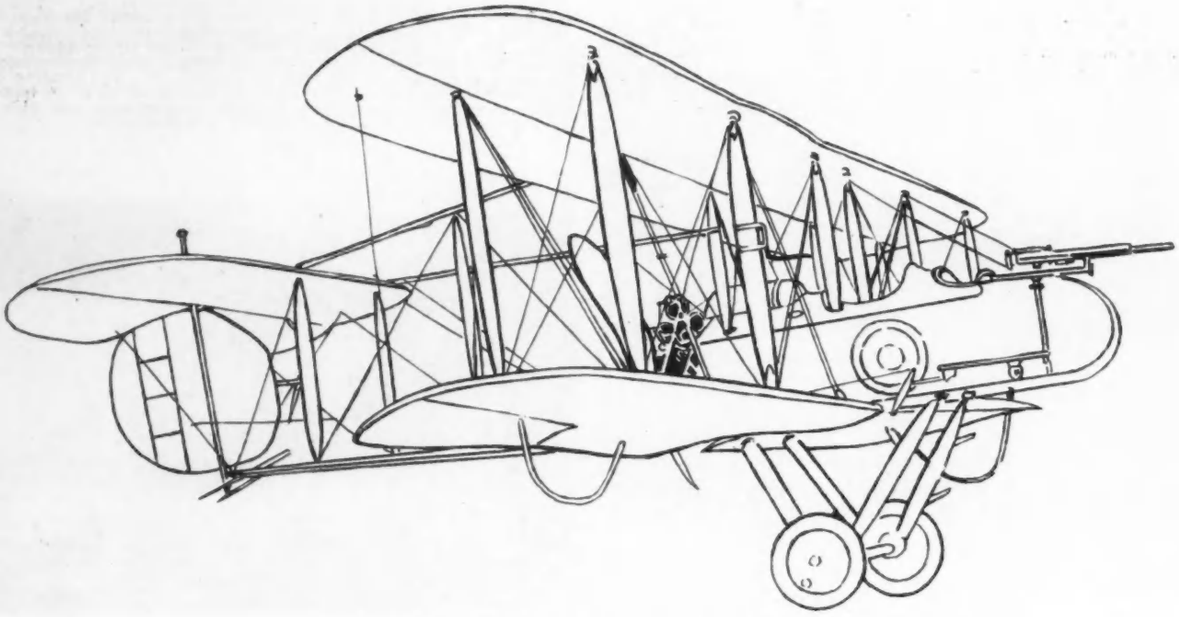
It will travel 125 m.p.h. The V-type Hispano-Suiza engine develops 200 hp. at 2000 r.p.m. It is equipped with a two-bladed propeller. The pressure gasoline tank has a capacity of 140 liters and the oil tank 15 liters.



SPAD TRACTOR BIPLANE

It has an air endurance of two hours. The radiator, fitted with shutters, forms the nose of the fuselage. It carries a fixed Vickers machine gun mounted above the body for the pilot. The weight of the machine empty, but including the cooling water, is 765 kg., the useful load 255 kg.

The above data are taken from *Flight*, May, 1918.



EARLY PUSHER—VICKERS "GUN BUS"

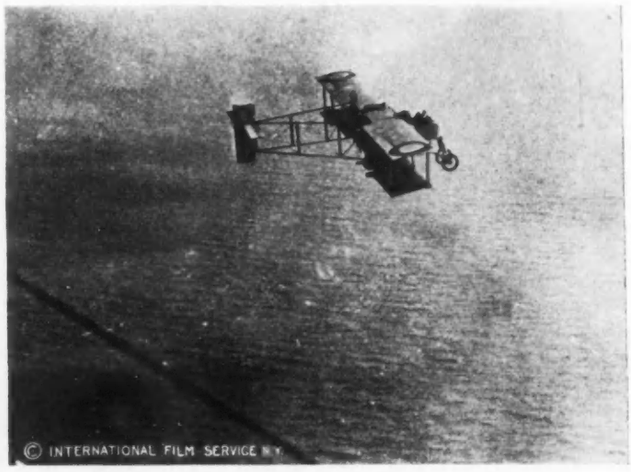
S.V.A. (ITALIAN) MACHINE

This machine is manufactured in a number of types similar to one another, the principal difference being in the wing spread and weight. The interplane strut bracing at either side of body is arranged in the form of a letter N. The upper span is 30 ft. 2 in., the lower 25 ft., the chord (both planes) 5 ft. 5 in., the gaps 5 ft. 11 in. and 4 ft. 11 in. The overall length is 26 ft. 7 in.; overall height, 10 ft. 6 in. Its weight empty is 1411 lb., weight loaded 1984 lb. It is equipped with a 210-hp. Spa engine. Its maximum speed is 125 m.p.h. It will climb 13,123 ft. in 14 minutes. The planes are in four sections; the top plane flat; the lower plane set at a dihedral angle. The wing curve has a negative tendency at the trailing edge, and the planes are given but a slight incidence angle or angle of attack. The trailing edge is flexible. A single set of ailerons are hinged to the upper plane. The steel tube interplane bracing is of stream-line section, as are the drift and anti-drift cables. The engine is entirely covered in at the forward end of the fuselage. The cowling runs back in straight line to the pilot's seat. The fuselage is narrow at the tail and exceptionally deep forward. The interplane struts sloping outward from the fuselage are not connected to the upper longerons but are carried part way down the vertical spacing members between the upper and lower longerons.

"BE2C" (BRITISH) MACHINE

VICKERS GUN BUS (FIRST TYPE OF BRITISH ARMED MACHINE)

This has an open type of fuselage, which has since been generally abandoned. It was one of the first successful pushers made and is still doing good work.



VOISIN (FRENCH) BATTLEPLANE

(3) *Battleplanes.* The battleplane is a two or three-passenger machine driven usually by one large or two fairly good-sized engines, and equipped with a number of machine guns and sometimes with a cannon. It is a moderately fast machine, making from 70 to 85 m.p.h. The Voisin is a good example of this type. It is credited with carrying a one-pounder.

TWIN-ENGINED CAPRONI BIPLANE (ITALIAN)

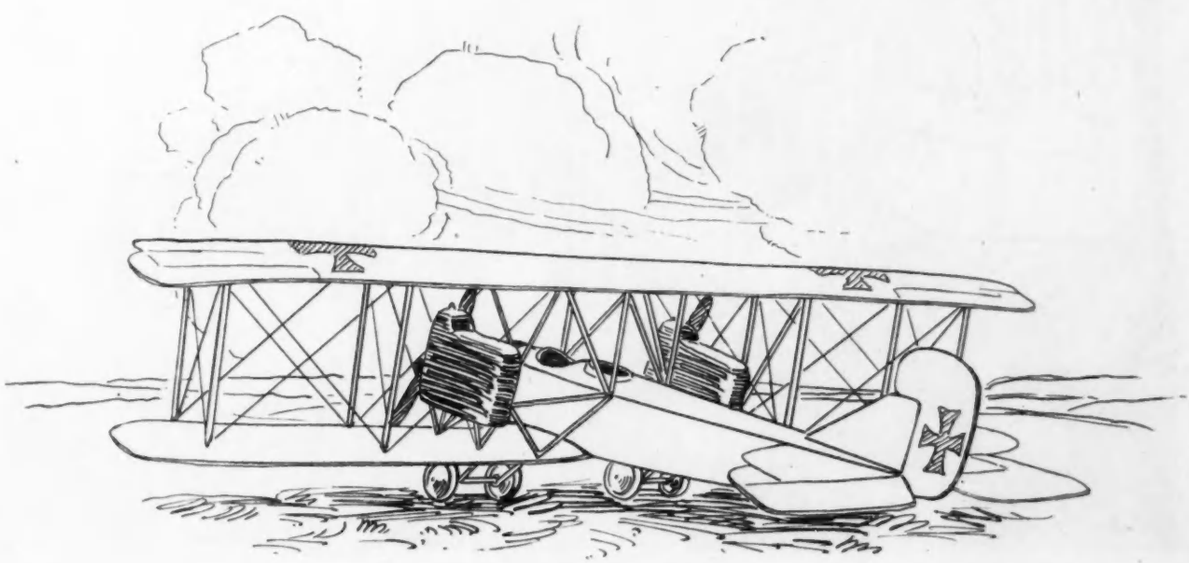
(4) *Bombers.* These are of the same general type as the reconnaissance machines but slightly larger. They vary in size from 45 to 90 ft. in wing spread, and carry from two to twelve people in addition to their war load of bombs and fuel. Their speed is from 75 to 100 m.p.h., their radius of operation from 500 to 1000 miles, and their climbing speed 7000 ft. in 30 minutes. Examples of large bombers are: Handley Page, Caproni, Breguet, the Caudron (a twin-engined French machine), the German Gotha, the Friederichshafen, the German A.E.G., and the big Curtiss boats. Machines that have been used for day-bombing and other purposes, but have lost their "pep" in remodeling, are often used for night-bombing.

TWIN-ENGINED A. E. G. (GERMAN) BOMBING BIPLANE

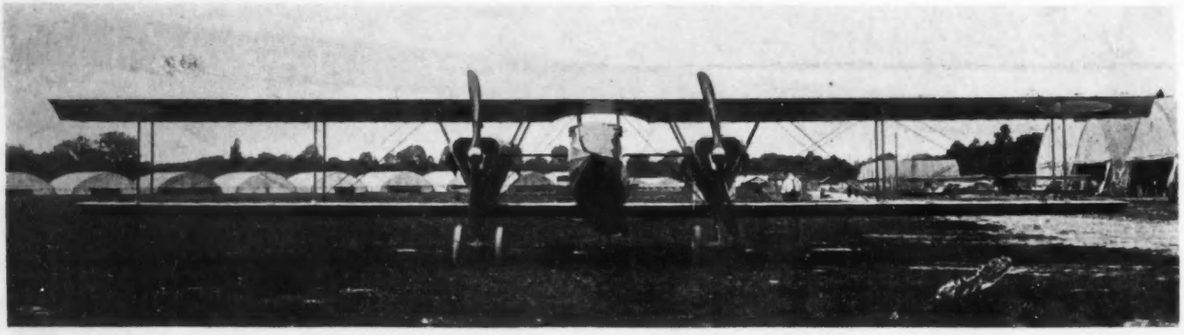
Basically the A. E. G. bomber is similar to the Gotha biplane, the latter being somewhat larger however; also the former has its two propellers placed in front of the main planes—the Gotha has pusher screws. The wings sweep back, are placed at a dihedral angle, appearing larger in the bottom than in the top plane. The span of both wings is the same, 57 ft., the overall length about 30 feet. The ailerons, peculiar in shape, are fitted to the top wing only and operated by a crank lever working in a slot. The tail wings, of monoplane type, have fixed stabilizing planes and a vertical fin-hinge to elevators and rudder respectively. Elevators and rudder have forward projections in order to partly balance them. The tail skid, which is under the stern of the fuselage, is sprung, not by rubber shock absorbers, but by coil springs. This is also the case with the landing chassis.

The material used in the construction is mainly steel; the ribs and main planes are of wood. The main spars are of steel tubes. The fuselage is built up of steel tubes, also the longerons, struts and cross members. These are connected by welding; the joints are stiffened and an anchorage provided for the cross bracing wires by triangular pieces of sheet steel welded to longerons and struts.

There are three divisions for passengers. The cockpit in the extreme nose provides a seat for the bomber, who sights through openings in the floor. A rack is placed at the right for holding bombs. Under the center of body there is another bomb-holding rack and near the inner ends of the lower plane there is space for more. The center cockpit has two seats for two pilots or two pilot gunners. Behind the pilot's cockpit is the gunner's, who operates a machine gun mounted on a turntable. The engines are generally of 260-hp. Mercedes type, and placed one on each side of the center section of the lower plane. The main gasoline tank is carried in the pilot's cockpit, and a service gasoline tank is fitted in each engine housing. The speed is not known, but is roughly estimated at about 90 m.p.h. The head resistance appears to be excessive.



A.E.G. (GERMAN) BOMBING BIPLANE



TWIN-ENGINED CAUDRON (FRENCH)

BREGUET BOMBER OF TRACTOR TYPE

This machine is an example of excellent stream-line construction and compactness, and its construction represents a marked advance in engine cooling. Attention is called to the louvers in the cowl.

BREGUET BOMBER (FRENCH)

and also to the clean opening between the panel and the fuselage. It is being used for bombing and has a great carrying capacity for its size. Its war load is 1900 pounds. It has a speed of 110 m.p.h. and will climb 12,000 ft. in 33 minutes.

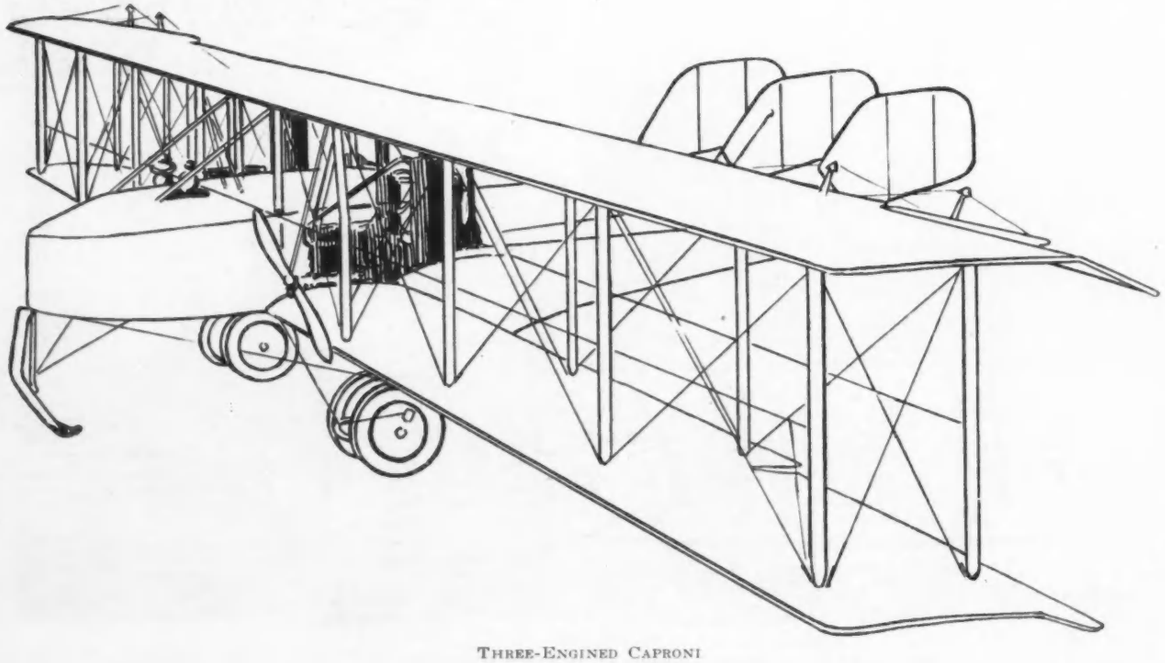
TYPES OF CAUDRON MACHINE

The Caudron G-4 has two rotary LaRhone engines carried in small nacelles between the planes. The pilot's nacelle is situated between the engine nacelles. The empennage is carried on four outriggers running back on a line with the engines, the lower outriggers acting as landing-skids. The four fins and four rudders are carried above the tail.

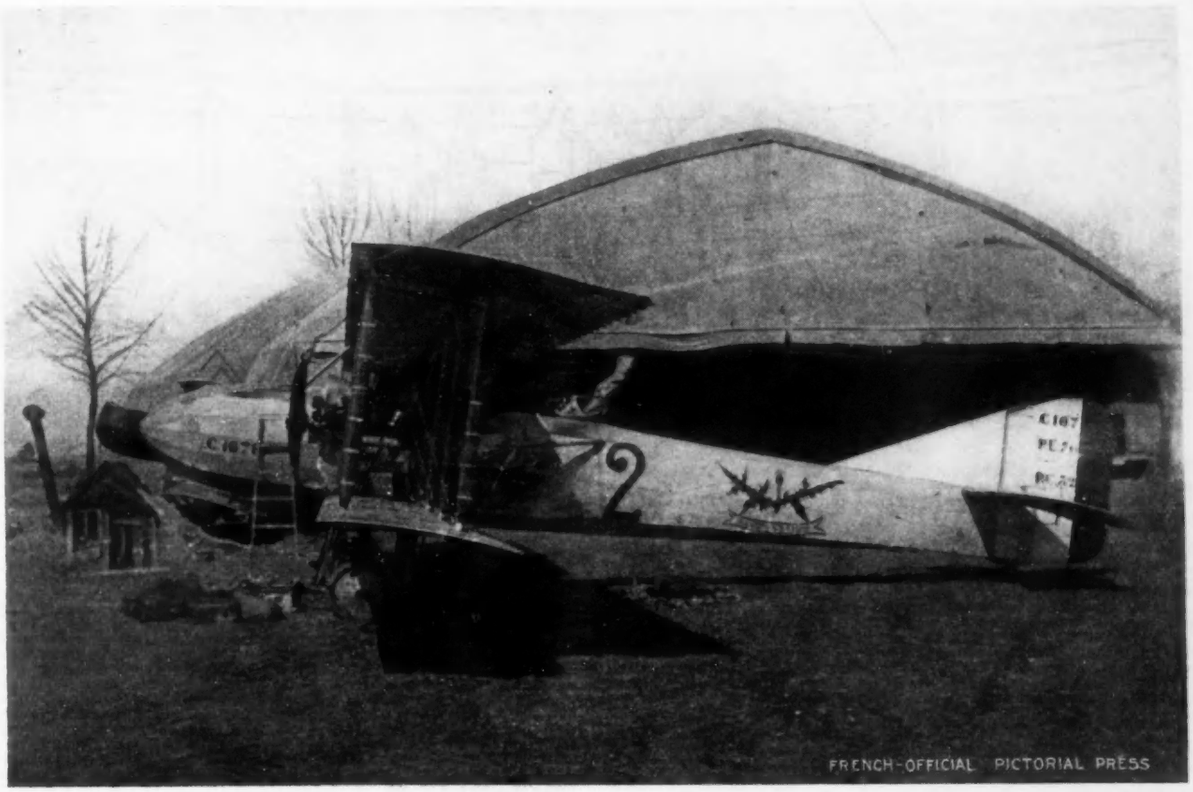
The Caudron G-6 has two rotary LaRhone engines and four landing-wheels. The upper wing is large with a considerable overhang. The lower wing is much smaller and narrower. The trailing edge is flexible. There are twin powerplants in line with the centerline of the landing chassis. The fuselage is fish-shaped and in the center of the machine. The two main struts are on either side of the engines; the outer forms part of the triangular truss with a slanting strut supporting the overhang of the wing.

In the Caudron R-4 the Hispano or Renault engine is used. The landing-gear is made up of five wheels, a set of two each under each engine and one small fifth wheel under the nose of the fuselage.

The Twin Caudron is a bombing machine, equipped with two 110-hp. LaRhone engines. The 1914 model was the first twin-engined machine ever built.

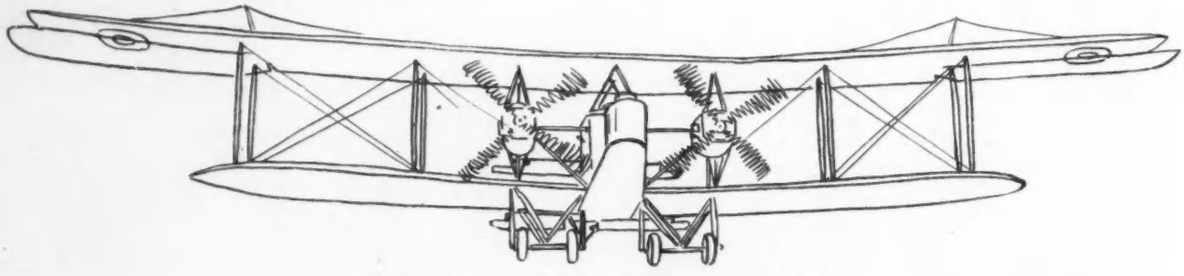


THREE-ENGINED CAPRONI



CAUDRON TWIN TRACTOR BIPLANE (FRENCH)

GERMAN GOTHA BOMBER BROUGHT DOWN BY FRENCH NEAR SOISSONS



HANDLEY-PAGE TWIN-ENGINED BOMBING BIPLANE

CAPRONI TRIPLANE WITH THREE ENGINES

It is equipped with three 200-hp. Fiat or Isotta-Fraschini engines, two located in the tractor position at the front of the fuselage and one pusher at the rear of the pilot's nacelle. It carries about a ton and a half. Next to the Curtiss triplane boat it is the largest triplane that has ever been built and successfully flown. It has five sets of struts on either side of the engines. The planes have practically no stagger, no dihedral and no sweepback. The empennage is very wide but has a small chord, and the elevator is a single narrow tail-flap with three balanced rudders above it. The landing-gear is composed of four pairs of wheels, one set under each fuselage. The fuselages are very long and only about half as deep as the gap. They are located just under the middle wing panel.

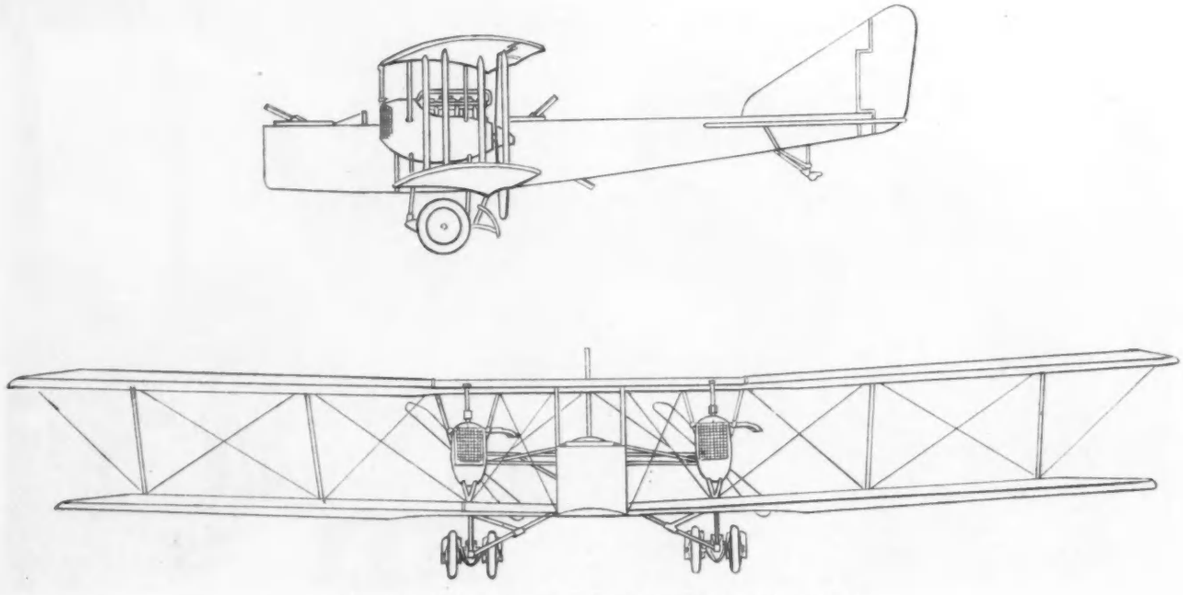
An unusual form of skid prevents the machine from turning over when landing. The machine is used for bombing and has a very large cruising radius.

FRIEDRICHSHAFEN BOMBING MACHINE

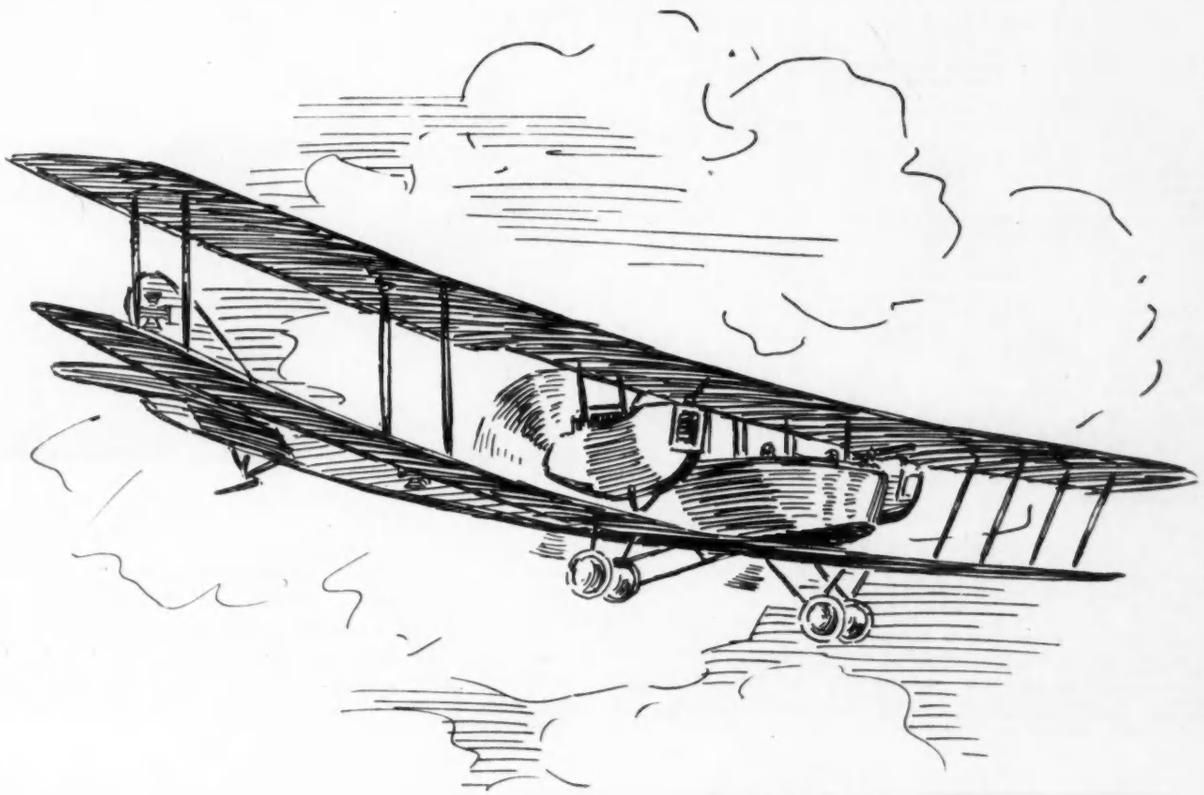
The Friedrichshafen is a twin-engined bombing airplane, very similar to a small Gotha; its chief difference, the sweepback of the wings, is a reversion to the earlier German practice. It is unlike the Gotha, in which the body is a monocoque, in that the body of the Friedrichshafen bomber is of the well known four-spar type with wooden cross members, suitably stayed. The forward portion, as far up as the engines, has a covering of veneer, the remainder of canvas.

The machine has an upper span of 20.30 m., a lower span of 18.85 m., with an overhang of 0.72 m. at the wing tips. The surface area of the wings is 70 sq. m. Its overall length is 11 m., overall height from ground to upper edge of rudder 4.10 m. The ailerons are of irregular shape and balanced at the wing tips (the construction being of steel tubing). The fixed tail wings comprise a triangular vertical fin and heart-shaped empennage. In the forward end of the body seats are arranged in tandem for the gunner and pilot, the pilot occupying the front seat. The main fuel tank is behind the pilot's seat with bomb-gears on either side of it; astern of this is a seat for the second gunner. A passageway runs through the body from the forward to the after seat, enabling the crew to change places when desired. The wing spars consist of steel tubes in the center section, and are built up of laminated wood beyond. The front spar is located very close to the leading edge, about 0.40 m. from the latter, while the rear spar is situated some distance from the trailing edge; the spars are spaced about 1 m. from one another. Unlike the Gotha, the wing ribs are parallel to the longitudinal axis of the machine. The German under-carriage differs considerably from German practice, as it bears, through the agency of suitable compression members, on the body as well as on the wing panels. It carries two water-cooled, six-cylinder, 225-hp. Benz engines, surrounded by a streamline bonnet. Its fuel tanks are situated in the body behind the pilot. The oil tanks are mounted underneath the radiators. The control is of the "Dep" type. The gross weight of the machine is 2200 kg., the fuel load 520 kg., and the useful load (crew and ammunition) 432 kg.

Its armament consists of three Parabellum machine guns, one each on the forward and after seats, on a gun ring upon which the gun carriage is made to slide by a lever. The latter permits the locking of the gun in a given position. The third gun is mounted on the floor of the body, on a pivot, and can be fired by the after gunner through a trapdoor operated by a lever. There is consequently no gun tunnel on this machine like the one on the Gotha. The central bomb gears are of the Gotha type. Six bombs are carried in a vertical row, in a self-feeding magazine. Additional bombs are carried amidships underneath the body in a spring-jaw suspension.



TWO VIEWS OF THE FRIEDRICHSHAFEN BOMBER (GERMAN)



FRIEDRICHSHAFEN

GOTHA

German Gotha Used Recently For London Raids

The span is 78 ft., and two Benz engines 225 hp. each are used. It is about the size of the Handley-Page, but is a pusher. It has large balanced ailerons and a long narrow monoplane tail; while the Handley-Page has a biplane tail. Three machine guns are carried, one in front, one at the rear cockpit and the third below it, which can be fired downward and backward through a gun-tunnel in the under surface of the fuselage. The nacelle has a channel cut through it in such a way that the gunner can walk along from one cockpit to the other. One gunner is located in the front cockpit, the other in the after cockpit with the pilot between. The machine has a double set of landing-gears, each set located under the engine nacelles. The upper wing has a slight overhang. The rudder and vertical fin are mounted very high. The planes have a noticeable sweepback and small dihedral.

Handley-Page British Bomber

This is a very large machine, in the same class as the Russian Sikorsky, the Italian Caproni and the giant Curtiss boats. Wing spread, 97 ft.; length, 47 ft.; and height, 15 ft. Chord, 9 ft. 6 in.; gap, 9 ft.; no stagger and no sweep back, a small dihedral, and an angle of incidence of 3½ deg. It carries sufficient fuel so it can stay up from 10 to 12 hours. Its gross weight is about 13,000 lb. and it carries a useful load of a little over a ton. Its maximum speed is about 88 m.p.h. and it will climb 10,000 ft. in 30 minutes. Powered with two 450-hp. Rolls-Royce engines. All-wood fuselage with passenger compartments below and a gunner's cockpit in the nose.

In spite of its size, the machine has been a great success, and it is to be expected that even larger machines of this character will be manufactured.

Voisin Pusher Type of Bombing Plane

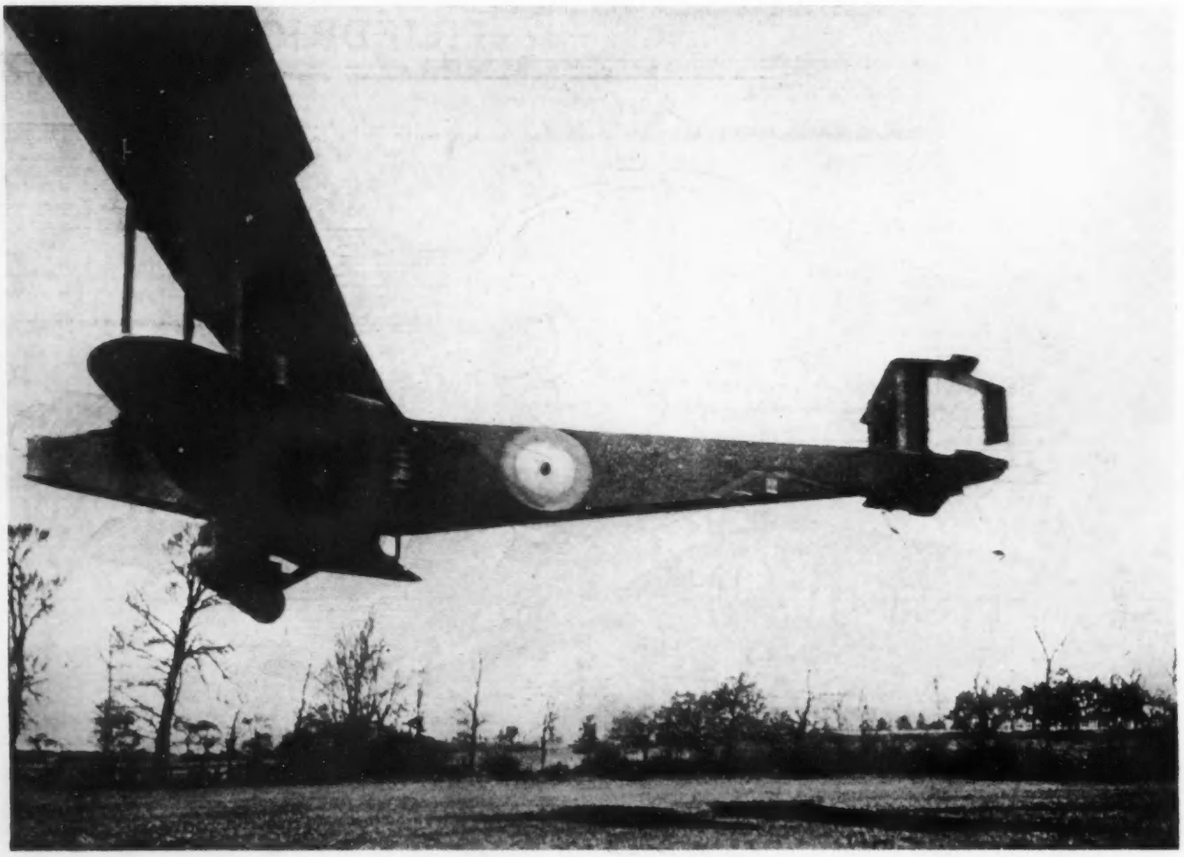
The Voisin of 50-ft. span carries a useful load of 1000 lb. The maximum speed is 80 m.p.h. and climbs 6000 ft. in 15 minutes. It is powered with a 150 to 200-hp. Renault engine, and has a cruising radius of 4 to 5 hours. The Voisin has no fuselage. It has a balanced rudder and a balanced elevator carried on four tubular outriggers, which terminate in a vertical knife-edge. There is no horizontal fin. The gunners sit very far forward.

Various engines are used: the Peugeot, the Renault and the Salmson. A small cannon and a machine gun are carried. Both pilot and gunner sit in front of the engine. The machine gun may be fired forward and backward over the upper plane.

Burgess U-2 Airplane (American)

Burgess "U"-2 Navy Seaplane.

The length over all is 30 ft. 5 in.; the width, 46 ft. 9 in.; height, 11 ft. 2 in.; chord, 6 ft. 3 in.; gap, 6 ft. Its supporting area is 574 sq. ft. The weight, when empty, is 1800 lb., its live load 600 with a 100-hp. Curtiss OXX engine. Its low speed is 48.3 m.p.h., its high speed 75.2 m.p.h. It will climb 300 ft. per minute.

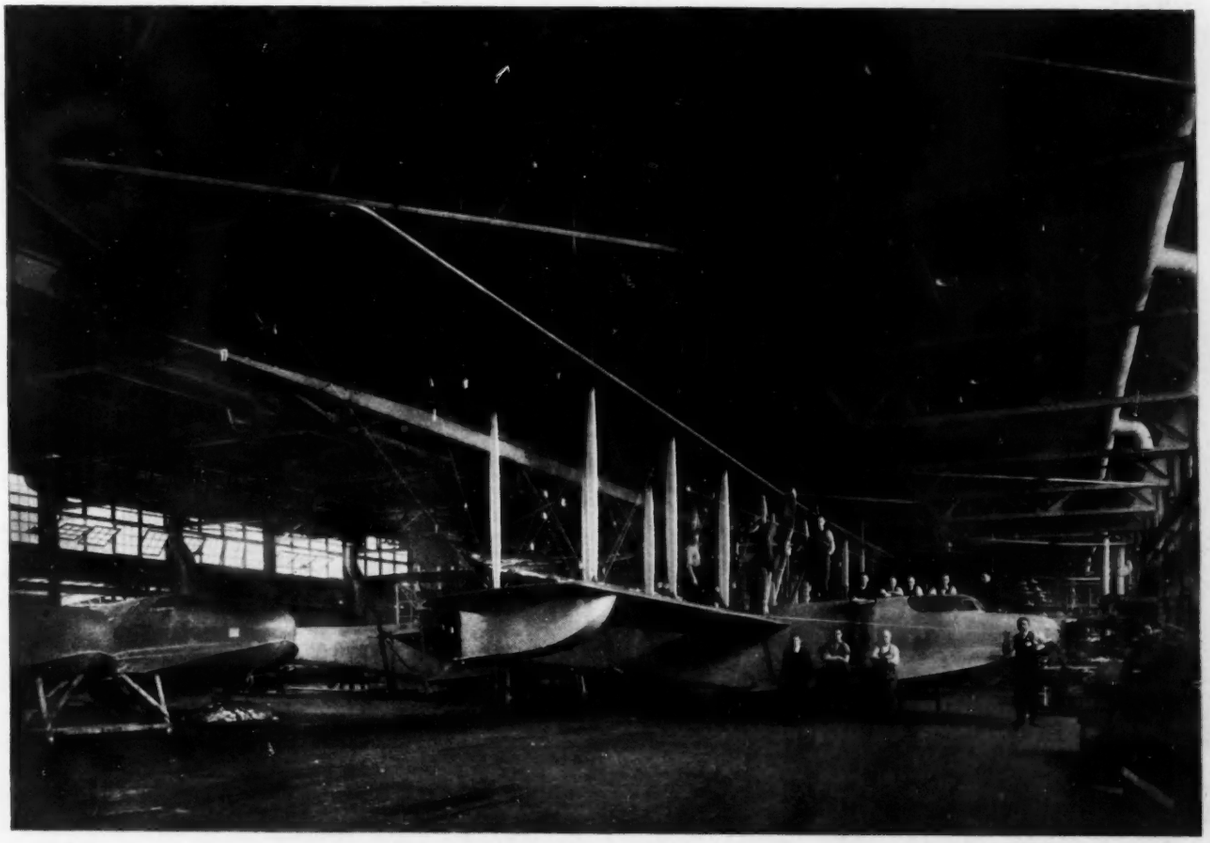


Handley-Page Bomber in Flight (English)

(5) *Flying-Boats and Seaplanes.* Various sizes of these are used for naval work. On account of the weight of their hull or pontoons these machines compare favorably with reconnaissance machines traveling at as high speeds as 90 to 100 m.p.h. Used for coast patrol work and for naval observation purposes, they operate from stations on the coast, battleships or motherships that accompany the fleet. Seaplanes are similar in construction to land machines, except that in place of the landing-gear, single or double pontoons are fitted below the wings so that the machine may rise from or alight on the water. Most seaplanes are lighter than flying-boats. For that reason, when a craft is desired for inland water work or for short scouting trips, the seaplane is considered by many to be a very desirable type. Unlike the land machine, it is not necessary to fly high in order to pick out a suitable landing place; one can land on the water almost anywhere. For larger sea voyages, however, especially when it is necessary for the craft to remain for some time away from its base of supply, a more seaworthy type of hull is necessary.

The large flying-boats, which the Curtiss Company has built in large numbers, are good examples of this type. These boats have a wing-spread of about 90 ft., are about 46 ft. long, and have a hull shaped very much like a sulphur-bottomed whale. The hull is 42 ft. long, the inside is electric-lighted, completely equipped, and so arranged that one can move about comfortably. A boat of this size will carry a little more than 2000 pounds. I have been told by English officers that this boat has given a good account of itself, and that a large number of pilots have been decorated for

CURTISS TRIPLANE HYDRO



ONE OF THE GIANT CURTISS FLYING BOATS (AMERICAN)

their splendid work in attacking and forcing Zeppelins down into the Channel.

FLYING-BOATS

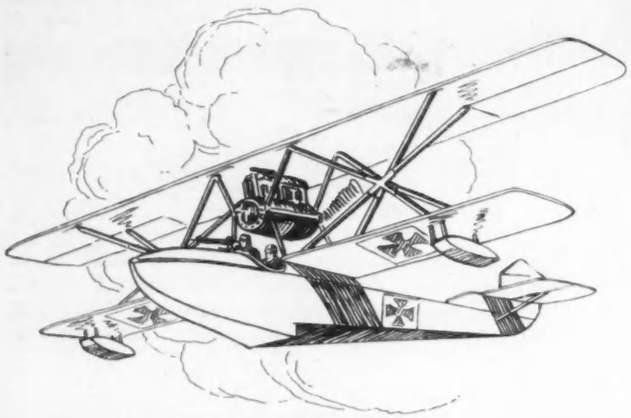
F. B. A. Flying-Boat of Pusher Type

Equipped with a Gnome, Clerget or 150-hp. Hispano-Suiza engine. It has a span of about 46½ ft., a chord of 6 ft., and a gap of 5 ft. 9 in. It is 32½ ft. long. The engine is mounted well up between the planes on an inverted V frame. There are three sets of vertical struts on either side with a set of inclined ones at the ends.

The after part of the boat comes to a rather sharp point. The fins and rudder are mounted at some distance above the hull. The front of the hull is whale-shaped with room for pilot and passenger side by side in a forward cockpit.

Ago Austrian Flying-Boat

This is a two-seater sea-going fighter. There are no wires employed in the structure of the wing cell, which is composed of two cross-networks consisting of a front spar and a rear spar and



Ago (an Austrian Flying Boat)

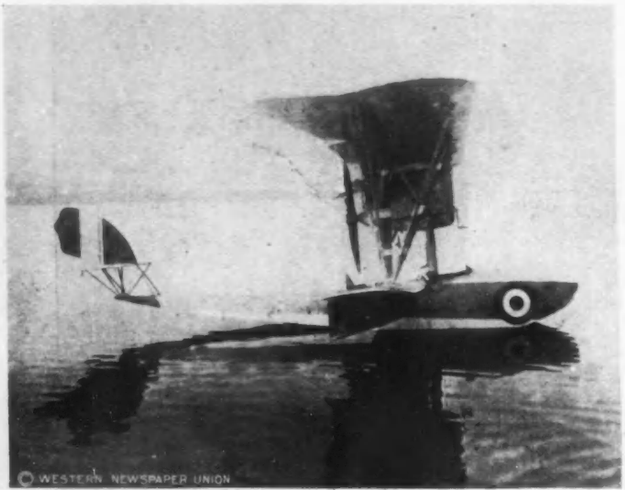
of adjacent struts in inclined planes connecting the spars. The struts are of steel tubing with a fairing of laminated wood with good stream-line effect.

The span of the upper plane is 8 m., the lower 7.38 m., and the chord for both planes is 1.50 meters. The length overall is 7.62 m. It is powered with a 218 hp. engine.

The carefully stream-lined shape of the hull and complete covering of cables and control wires are designed to decrease head resistance as much as possible.

Macchi Flying-Boat (Italian)

This boat has a very peculiar tail, Nieuport V-type of strut, is a pusher type and is very fast. Single-seater, fine construction,



Macchi Flying Boat (Italian)

light weight, high-powered engine, quick climber. Head resistance slight. Struts and interplane bracing similar to Nieuport. Isotta-Fraschini engine. Overall dimensions: span 39 ft. 4 7/16 in.; length, 27 ft. 3 in.; height, 9 ft. 10 1/16 in.

Austrian Löhner Flying-Boat

In this six steel struts are placed on either side, and, two by two, are connected in transverse planes with steel tubes. The upper plane span is 9.70 m., the lower span 7.20 m., the chord of the upper plane 2.70 m.; that of the lower, 2.20 m. The

Löhner Flying Boat (Austrian)

length of the hull is 12.50 m. The capacity for carrying bombs is 400 kg.

It is equipped with a 300-hp. Austro-Daimler twelve-cylinder V engine.

Sturtevant S-4 Hydro (American)

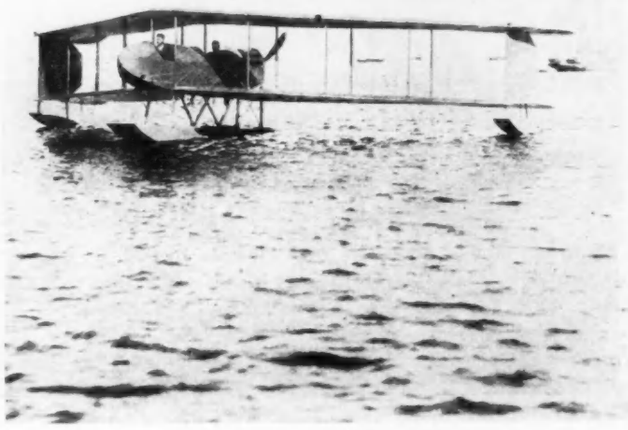
S-4 Seaplane (Sturtevant Airplane Co.)

The supporting surface of the upper wing with ailerons is 313.2 sq. ft.; of the lower wing with ailerons 299.4 sq. ft. Elevator: fixed plane, 33.6 sq. ft. Rudder: fin 4.3 sq. ft.; flap, 10.9 sq. ft. It is equipped with Sturtevant Model 5-A 140-hp. engine.

Rumpler Seaplane (German)

BURGESS-DUNNE SPORTING SEAPLANE

It has a length overall of 24 ft. 8 in.; width, 48 ft. 3 in.; extreme height, 10 ft. 3 in. The main surface area is 4954 sq. ft. The weight, when empty, is 1750 lb.; loaded, 2317 lb. It is equipped with a 100-hp. Curtiss OXX engine. Its low speed is 48.3 m.p.h., its high speed 75.2 m.p.h. It will climb 300 ft. per minute.



BURGESS-DUNNE (AMERICAN)

MARTIN (AMERICAN) TRAINING PLANE

MARTIN MODEL R. (THE GLENN L. MARTIN CO.)

This machine is equipped with a six-cylinder Hall-Scott engine.

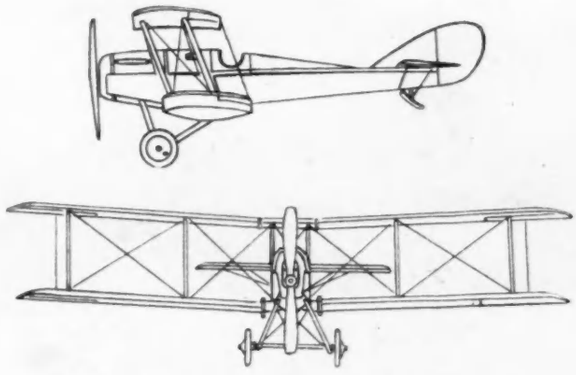
Overall length, ft.	26.7
Overall height, ft.	11.3
Overall span of upper wing, ft.	50.7
Overall span of lower wing, ft.	36.9
Chord length, ft.	5.5
Gap, ft.	6.0
Dihedral angle of wings, deg.	1.5
Total supporting area, sq. ft.	405.4
Gross flight weight, lb.	2864.9
Dead weight, lb.	1904.9
The performance at 1375 r.p.m. in the air is:	
Useful load, lb.	900.
Speed maximum, m.p.h.	73.0
Speed minimum, m.p.h.	49.0
Climb in 10 minutes, ft.	3100.0
Fuel capacity at full load, hours	4.5

TRAINING MACHINES

ARMSTRONG-WHITWORTH (90-HP. R. A. F. ENGINE)

Two-seater, tractor stick-controlled biplane school machine. Aspect ratio, 7. Dihedral at the top, 3½ deg.; at the bottom 2½ deg. Stagger, 1 ft. 11.6 in., a chord of 5 ft. 8.3 in., gap 5 ft. 10.9 in., and angle of incidence 2½ deg. It is equipped with R. A. F. 90-hp. air-cooled engine, which at 1700 r.p.m. drives a four-bladed propeller of 9 ft. diameter, 10-ft. pitch. It carries a military load of 80 lb., a human load of 360 lb., total load of 440 lb. The weight hp. ratio is 22.8. Span, 40 ft. Overall length, 28 ft. 9 in. It will climb 10,000 ft. in 49 min., and has a speed of 72 m.p.h. Total weight, 2050 lb. The air endurance is 3 hours. It consumes 9.3 gal. of gasoline and 3.3 pints of oil per hour.

Length of run to unstick 85 yards. Length of run to pull up (engine stopped) 120 yards. Single stick control. It will climb 12,300 ft. in 78 min.; rate of climb 75 ft. per minute.



SIDE AND FRONT VIEWS, MARTINSYDE SCOUT

MARTINSYDE SCOUT TRACTOR BIPLANE

One-seater, powered with a 120-hp. Beardmore, which drives a two-bladed, 9-ft. 6-in. propeller with pitch of 6 ft. Span, 38 ft.; chord, 5 ft. 11.75 in. Gap, 5 ft. 8 in. Overall length, 26 ft. 6 in. It is moderately fast, making 98 m.p.h. near the ground and climbing 3000 ft. in 4 min. The complete machine unloaded and dry weighs about 1400 lb.

STURTEVANT SCOUT (AMERICAN)

STURTEVANT SINGLE-SEATER SCOUT

It has pyramid trussing. This is a half-wing feature made by the stream-lining of the single lower spars. The stationary engine is carefully cowled. Overhead radiators are set into the wings. Its design affords a wide range of view and good facilities for mounting a machine gun. Its compactness is notable. All structural parts are built of vanadium steel. It is fitted with 150-hp. Sturtevant engine, of the eight-cylinder water-cooled type. The net weight is 1000 pounds.

THOMAS-MORSE SCOUT (AMERICAN)

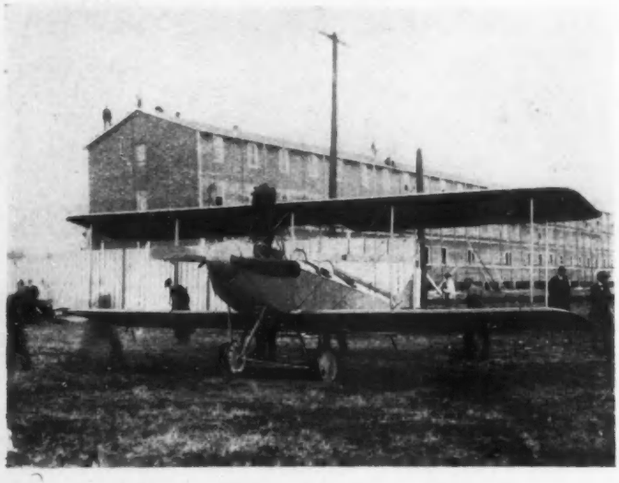
S-4-C SINGLE SEATER (THE THOMAS-MORSE CO.)

This is fitted with 100-hp. Gnome or LeRhone 80-hp. engine. It has a wing spread of 27 ft.; length over all, 18 ft.; total weight, fully loaded, with Gnome engine, 1350 lb.; weight fully loaded with LeRhone engine, 1300 lb. It has a climbing speed of 9500 ft. in 10 min. with the Gnome, and 8500 ft. in 10 min. with the LeRhone. It has a high speed of 105 m.p.h. with the Gnome and a high speed of 95 with LeRhone.

AUTHOR'S CONCLUSION

American manufacturers are not standing idle as some people seem to think. There have, of course, been many discouraging delays—many of which might have been prevented, many of which could not. I believe, however, that we are now fairly well on our way to good and continuous production.

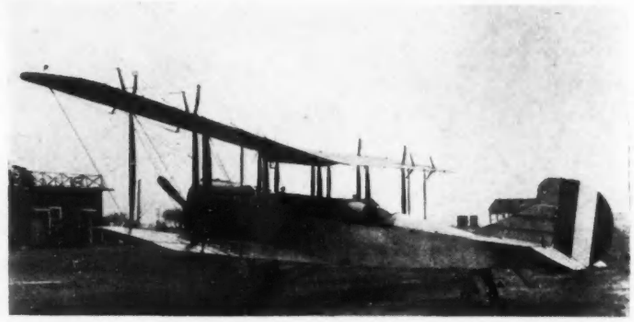
Americans are known as great manufacturers and great inventors. American inventive genius always has and I believe always will continue to lead the world. Out of the brain of the Americans came the airplanes of yesterday and out of their brains will come, I believe, hundreds of improvements that will make the airplanes of tomorrow equally radical in their epoch-making possibilities.



"STANDARD" SCHOOL MACHINE (AMERICAN)

We will win this war; why? Because it is a war of democracy against autocracy, a war of mental freedom against mental domination, a war of right against wrong.

Right will conquer, it always has and it always will. Humanly speaking, this war is a mechanical war, a war to be waged and won with machines directed from the air. It is a war that our *red*-blooded young men, in whose hearts has been kindled the *white* heat of true patriotism, flying in the *blue* sky of an ever-increasing democratic world, will, with the help of almighty God, fight to a glorious and victorious end.



CURTISS "MAIL" MACHINE

NOTE:—The author desires to express his appreciation of the courtesies extended to him by the officials of the Allied Military Commissions and officials of the United States Government, the aeronautical press, particularly the publishers of *Flight*, *Aeroplane*, *Flying*, *Aviation* and *Air Travel*, for the valuable assistance rendered to him in the collection and preparation of these data.

LWF WITH STURTEVANT ENGINE (AMERICAN)

He wishes to thank those members of the Manufacturers' Aircraft Association who have liberally provided photographs and specifications for the American section of the paper; and also the Curtiss Research Department in permitting the use of its analysis of the importance of numerical superiority.

APPENDIX—IMPORTANCE OF NUMERICAL SUPERIORITY

The English pioneer in the science of aeronautics, F. W. Lanchester, has several chapters in his book, "Aircraft in Warfare," which merit far more attention than they have yet received. The book is teeming with predictions written during the period immediately following the outbreak of hostilities (September to December, 1914), which by now have been borne out in a most complete and astonishing fashion.

Two chapters on the effect of concentration are especially interesting when applied to aerial welfare, and they point the way clearly toward aerial supremacy. The results are given without demonstration, and partly on this account, as well as on account of the intrinsic information attached thereto, the chapters seemed to us to be not without interest, especially at the present time.

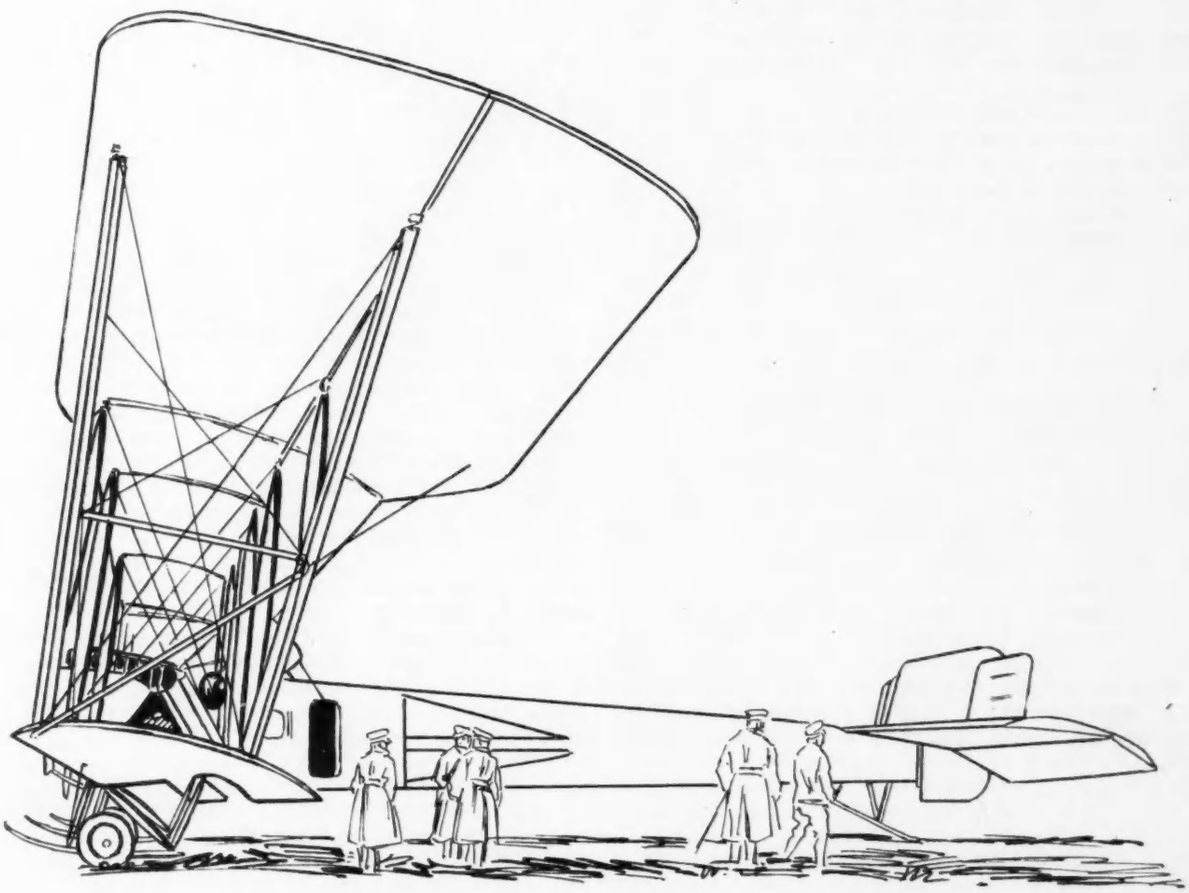
The devising and building of a new type of airplane which has "quality" superiority over the best existing type is a slow, difficult and costly process. The emphasis is on the word "slow." Time is precious just now, and an important question immediately arises. By what factor can "quality" be overcome? The answer is conclusive. It is "numbers" or "quantity." We do not deny any advantage derivable from quality, but quantity is at once obtainable.

A number of efficient fighting machines of the different types are in existence today. Any new "quality" that can conveniently be incorporated in the machines is, of course, an added advantage, but as Mr. Lanchester shows, the superiority of quantity is overwhelming.

In the past, when fighters met man to man, it was seldom that many concentrated upon one; superiority in numbers was almost in direct proportion to the numbers themselves; the losses were about equal, under conditions equal except as to numbers, and the more numerous won on that account alone.

"Nowadays, with firearms, the possible concentration of superior numbers gives an immediate superiority in the active combatant ranks, and the inferior force finds itself under a far heavier fire, man for man, than it is able to return."

We have made some calculations of our own, based on an assumption stated clearly by Lanchester. His statement amounts to the following: The rate of mortality in one group of fighters is directly proportional to the numbers (and to the quality) in the opposing group, and vice versa. The results of this assumption are certainly, at first sight, astonishing. While no one claims that battles are fought which result in an exact agreement with the calculated results, the general principle is so definite and convincing that its approximate validity cannot seriously be questioned.



GIANT SIKORSKI BIPLANE (RUSSIAN)

Lanchester says: "There are many who will be inclined to cavil at any mathematical or semi-mathematical treatment of the present subject, on the ground that, with so many unknown factors, such as the morale or leadership of the men, the unaccounted merits or demerits of the weapons, and the still more unknown "chances of war," it is ridiculous to pretend to calculate anything. The answer to this is simple: the direct numerical comparison of the forces engaging in conflict, or available in the event of war, is almost universal. It is a factor always carefully reckoned with by the various military authorities; it is discussed *ad nauseam* in the press. Yet such direct counting of forces is in itself a tacit acceptance of the applicability of mathematical principles, but confined to a special case. To accept without reserve the mere "counting of the pieces" as of value, and to deny the more extended application of mathematical theory, is as illogical and unintelligent as to accept broadly and indiscriminately the balance and the weighing machine as instruments of precision, but to decline to permit in the latter case any allowance for the known inequality of leverage."

We have made some calculations along the lines suggested by Lanchester, with the following results:

	Group I, Initial Number, 2000				Group II, Initial Number, 1,000			
	Ability Ratio	Final Number	Lost		Time	Final Number	Lost	
			No.	%			No.	%
	A B							
Case I...	1 to 2	1413	587	29.4	0.881	0	1000	100
Case II...	2 to 3	1581	419	21.0	0.713	0	1000	100
Case III..	1 to 1	1732	268	13.4	0.550	0	1000	100
Case IV...	3 to 2	1826	174	8.7	0.433	0	1000	100
Case V...	2 to 1	1871	129	6.5	0.370	0	1000	100

This table shows conclusively that numerical superiority is the controlling factor in every case considered, even with the quality factor against it. The first case is especially interesting in this respect; in this a number of machines fighting one-half that number, but of twice the quality, win out with a loss of 30 per cent, as compared to a loss of 100 per cent in the smaller group. With these equations it is, of course, possible to calculate the advantage to be derived by separating by superior strategy, the equally numerous enemy group into two groups and separately annihilating them.

For example, a force x of 1000 meets separately a force y of 500 machines. The result is that the 500 are destroyed with a loss of only 134 in the x force. This leaves 866 of the x forces opposed to 500 new y forces, which they can destroy with a loss to themselves of only 159 more, making a total loss in the x forces of only 293 against 1000 enemy forces.

These results lead us to investigate specifically the effect of quality as compared to quantity.

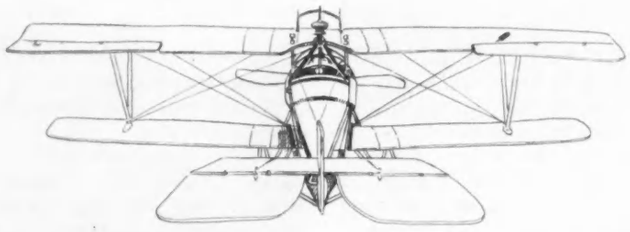
The effect of quality was also gone into, and by demonstration slightly different from Lanchester's we obtained a law that the fighting strengths of two opposing forces are equal when the product of their quality factor and the square of their numbers respectively are equal.

The importance of this result, in our opinion, is that when competition in quality of machines is as keen as it now is between warring nations it is clear that no great further improvement in quality can be made. No machine of a given type is four or nine times better than the same type of the enemy's, or vice versa. The main aim should be superiority in numbers. It is far easier to build large numbers of a standard type of machine than to devise new types appreciably better than competing ones. This law states that a group must have a quality four times as great as the quality of the opposing group to overcome twice the numerical superiority; it must have a quality nine times as great to overcome a numerical superiority of three.

No such quality increase is obtainable at the present unless by the discovery of some fundamental new principle. The usual improvements in quality are gradual refinements in construction.

For other calculations and details the main article should be consulted.

The main reason, however, for bringing these results before the reader at the present time is that "numbers do count," and that we should make every effort to increase the numerical output without losing too much time in making refinements.



Vol. III. July, 1918 No. 1

Oil Wells in the Cimarron River, Oklahoma

Petroleum Refining

By C. W. STRATFORD* (*Member of the Society*)

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

THE general subject of petroleum refining is so encyclopedic in both scope and character as to preclude more than a rapid survey of its principal elements and the mention of some of the many important details.

As a preliminary to the main subject, which deals with the refining of a given crude petroleum, a few remarks are necessary concerning all crude petroleums, their occurrence and distribution, and their physical characteristics and chemical structures.

There has been much discussion among scientists on the subject of the origin of petroleum but as yet no agreement as to theory has been reached. Two general theories have been advanced, the organic and inorganic. The inorganic theory in general holds that hydrocarbons have been produced by the action of water or carbon dioxide on highly heated alkali metals, or by the action of water on metallic carbides. The organic theory can be subdivided into the animal and vegetable theory. Hydrocarbons can be easily produced by the destructive distillation under pressure of both animal and vegetable oils. For example, if a fish oil such as menhaden is closed in a tube and heated to a temperature of about 350 deg. cent. at a pressure of ten atmospheres only hydrocarbons will be found present on opening the tube. This is a well defined instance of the decomposition by heat of animal matter into hydrocarbon compounds. Further, it is well known that the decomposition of vegetable matter in swampy lands gives off methane or marsh gas. The destructive distillation of peat yields hydrocarbons very similar to those found in crude petroleum.

Petroleum occurs in practically every country in the world. It is found floating on the surface of water, as exudations on the earth's surface, and in the geological formations which make up the crust of the earth, at depths sometimes exceeding 3,000 feet. Crude petroleum is a highly complex mixture of compounds of hydrogen and carbon. The ultimate chemical analysis of petroleum show they contain approximately 80 to 88 per cent of carbon and from 10 to 15 per cent of hydrogen. The impurities present are chiefly compounds of sulphur, nitrogen, oxygen and metallic salts. The occurrence of liquid petroleum is usually closely associated with that of water.

The most obvious physical characteristics of crude petroleum are gravity, color, odor, viscosity, volatility and chill point. All of these properties vary widely with the source of the crude petroleum. Gravity varies from about 9 deg. Baumé for one type of Mexican crude to 65 deg., which is practically pure gasoline issuing from some freak wells. Color ranges from water white through different shades of yellow, green, brown to jet black. The odor varies from that of sweet ethereal light hydrocarbons to ill-smelling sulphur and other compounds. Some crude petroleums possess such a high volatility as to permit their use, without processing, in a gasoline engine, while others contain almost no volatile products. Variation in viscosity ranges between very light agile fluids to a semi-fluid consistency. The variation of the chill point is mainly dependent upon the percentage of paraffin wax contained in the oil.

Oil refiners divide petroleum into two general groups, the paraffin base and asphaltic base. Petroleums belonging to the paraffin base contain paraffin wax. Those belonging to the asphaltic contain practically no paraffin wax. There is no sharp line of demarcation, however, between the general paraffin and asphaltic groups, since petroleums are found, notably in the mid-continent field, that contain both asphaltic compounds and paraffin wax.

The hydrocarbons found in different petroleums consist chiefly of those belonging to the paraffin (C_nH_{2n+2}), olefin (C_nH_{2n}), and polymethylene ($C_nH_{2n-6+6H}$) group series. Many other unsaturated hydrocarbons belonging to the chain and cyclic series have been identified but they are usually present only in very small quantities. It may be broadly stated that all petroleums contain about the same number of series of chemical compounds. The general characteristics of the different petroleums and their finished products are determined by the proportion of the paraffin, olefin, or polymethylene compounds present.

*Consulting petroleum technologist, New York.

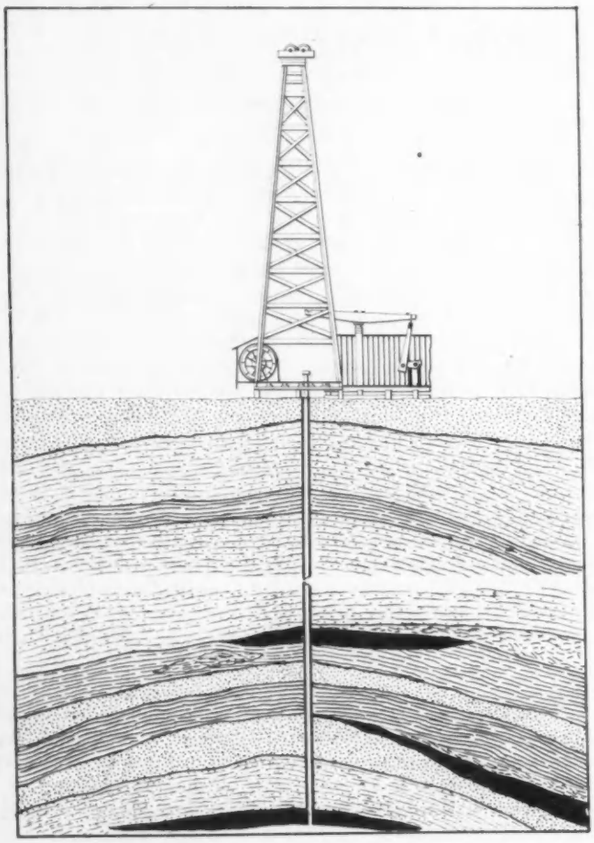
The problems with which the refiner is confronted in the manufacture of his products consist essentially of a preliminary separation by distillation of petroleum into roughly defined groups, the chemical treatment of distillates, secondary distillation, chilling, pressing, sweating, reducing (distillation) and filtering. After the distillates have been purified by the refining processes they are finally blended into their ultimate market grades. Of great economic importance in the refining of petroleum are the conversion by cracking under pressure of distillates and still residues of low market value into gasoline and fuel oil and the recovery and utilization of by-products, such as gum (wax tailings) still coke, acid cake and asphalt.

REFINERY STORAGE TANKS

The storage capacity for crude petroleum provided at the average refinery is sufficient for from ten days to one month's full operation of the refinery. The storage tanks are separated by fire dams of earth so that in case any tank becomes ignited and the burning oil flows out, the fire will be localized within the dams

REFINING OF PENNSYLVANIA PETROLEUM BY STEAM DISTILLATION

There are four general types of distillation applied to crude petroleum and its distillates: (1) *Destructive*, in which heat is applied directly to the still by coal, gas, or oil fires alone; (2) *vacuum*, in which heat is applied to the still by a direct fire while a vacuum of about 15 in. Hg. is maintained on the contents of the still and within the entire condenser systems; (3) *fire and steam* (reduced pressure), in which fire is applied to the still and open steam is continuously bubbled through the boiling oil; and (4) *steam*, in which there is no direct fire, all of the heat required for the distillation being supplied by closed steam coils arranged within the still. Distillation under vacuum, in a commercial way, has long since been discarded by refiners in preference to the fire and steam method. The latter method gives better results and at a lower cost. The distillation of petroleum with open steam is universally practised for the purpose of minimizing the chemical decomposition which always occurs when heavy hydrocarbons are distilled. The water vapor, intimately mixing with the oil vapors within the still, help to support the atmospheric pressure and thus reduces (partial vapor pressures) the total pressure on the oil and its vapors. This condition has the effect of lowering the boiling points of the hydrocarbons and almost entirely preventing their decomposition or polymerization.

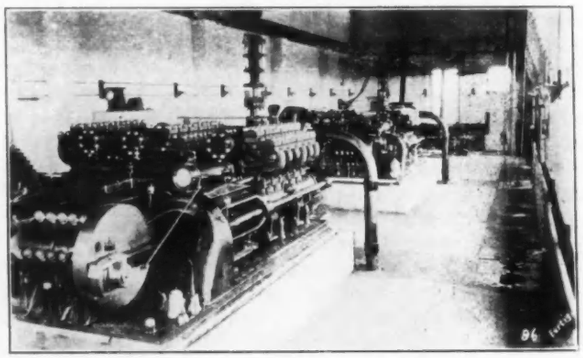


GEOLOGICAL STRATA, SHOWING OIL POCKETS (BLACK SPOTS)

Steam stills equipped with closed steam coils are used only for the distillation of fairly volatile products.

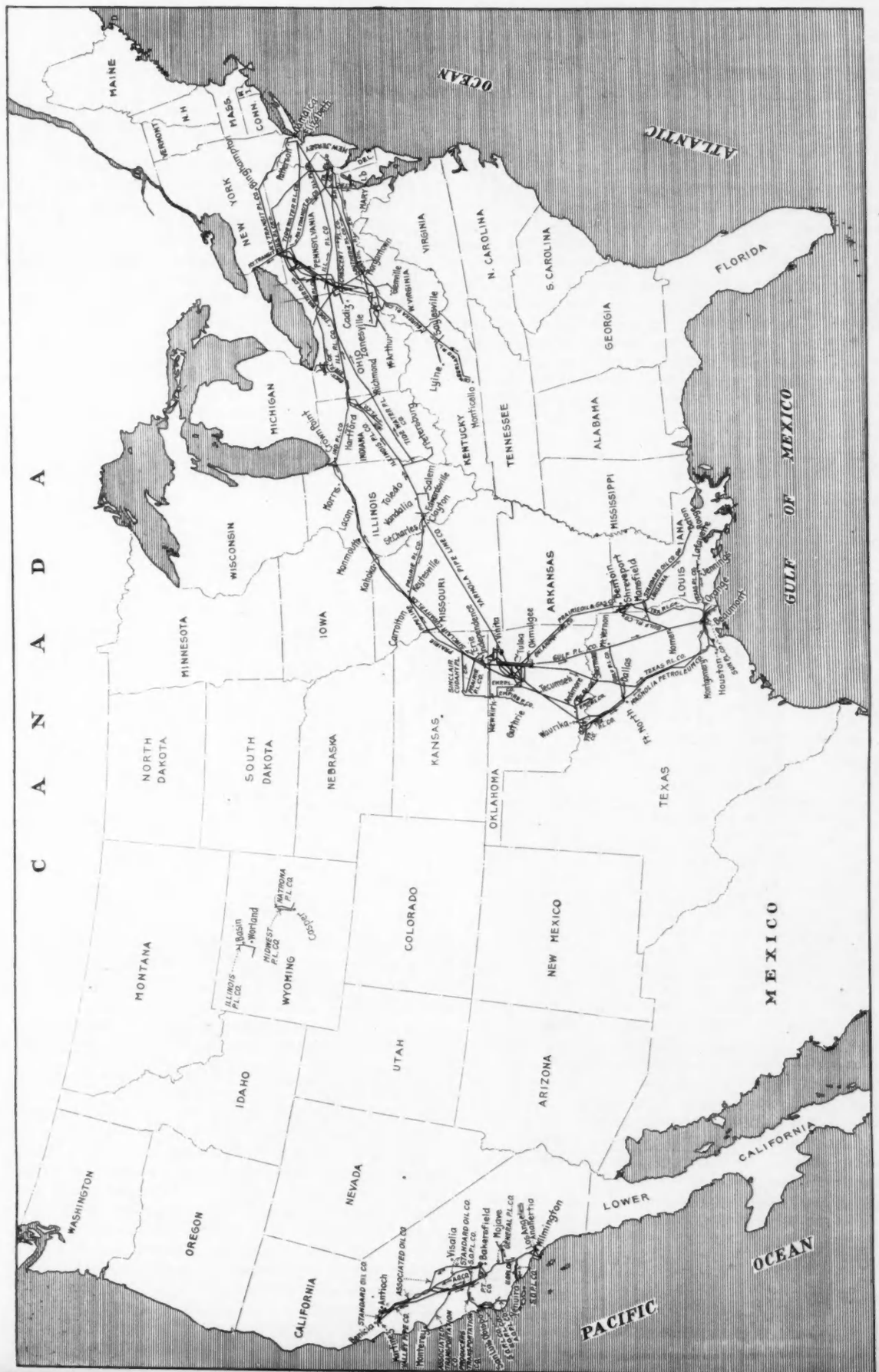
Preliminary Group Separation

From the storage tank the petroleum is pumped into a crude still under which a fire is started. If the petroleum contains water the still commences to "bump" vigorously as it heats up and continues to do so until all the water has been driven off. In case the petroleum contains no water the still "sings" at first, very much like a tea kettle, which is explained by the fact that all petroleum contains more or less dissolved gas which is driven out of the oil as it warms up. As the temperature of the still rises and the oil commences to boil, the first con-



PIPE LINE PUMPING STATION

Typical pumping station of pipe line between oil fields and refineries. As an example of capacity: Distance between stations, 50 miles. Line, 6 inches. Pressure at sending station, 660 lb. per sq. in. Horsepower required, 182. Total oil pumped in 24 hr., 13,128 forty-two-gallon barrels, or about 3 bbl. per horsepower per hour. The viscosity of petroleum pumped and topography of country over which pipe line passes determines distance between pumping stations; minimum about 15 miles and maximum about 100 miles.

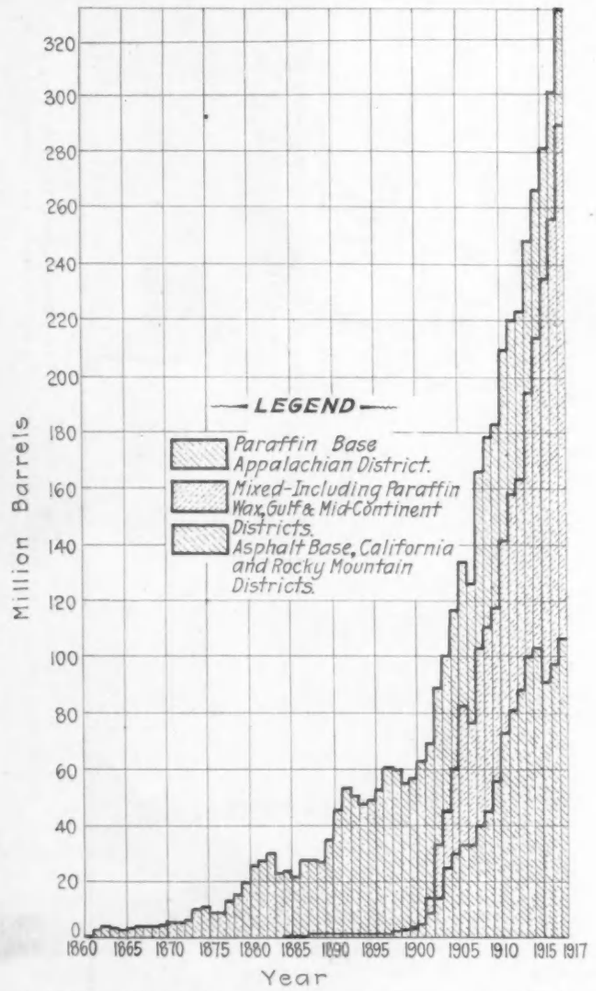


PIPE LINES IN THE UNITED STATES (1916) LEADING FROM OIL FIELDS TO REFINERIES
(From Map Prepared for United States Geological Survey under the Supervision of John D. Northrop)

densable distillate that comes over is light gasoline. As the stream continues to run, the distillates become heavier and heavier, and distillation is continued until about 15 per cent of the total original charge remains in the still.

The distillates from beginning to end are cut or separated into (1) crude gasoline, (2) crude illuminating oils, (3) gas oil, and (4) lubricating distillate. The heavy residual oil, crude cylinder stock, remaining in the still is allowed to pass into a run-down tank. Commercial crude stills are usually equipped with aerial condensors of different types, but the function of all types of aerial condensors is the same; namely, that of selective condensation.

At the beginning of a distillation the first light distillate collects in the bottom pan or in the first chamber of the condensor. As distillation proceeds, however, the lightest distillate progresses successively through the different chambers until a point is reached when distillates varying widely in volatility collect simultaneously in the different pans of the aerial condensor, ranging in viscosity from light to heavy. Each pan of the aerial condensor is connected by way of the tail house to run-down tanks.



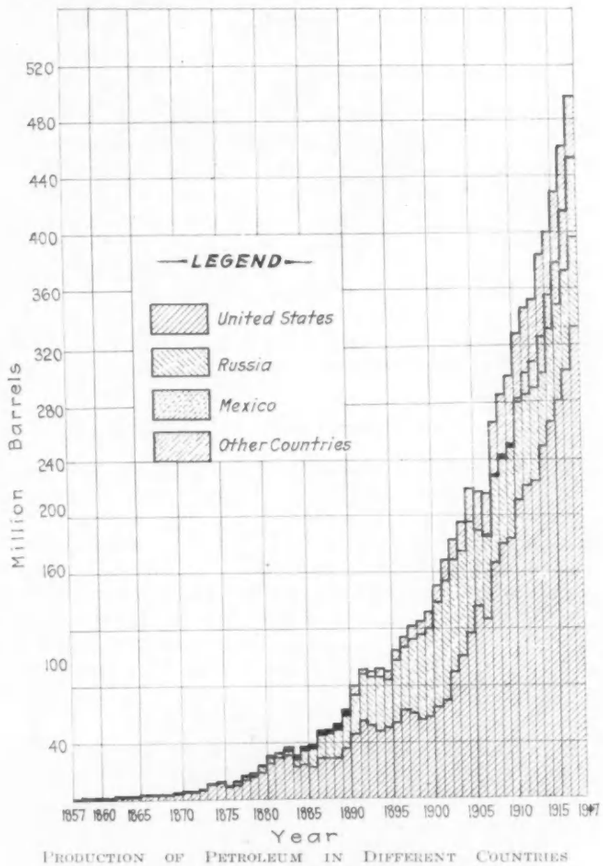
UNITED STATES PETROLEUM PRODUCTION (FROM DATA SUPPLIED BY U. S. BUREAU OF MINES)

Subsequent Processing Methods

Any description of processing methods can never be absolute in all the details since there are as many or more variations in these processing methods as there are distillates and residuals processed. The following discussion of subsequent processing methods therefore does not pretend to be absolute but it is substantially representative of refining processes as applied to products derived from the distillation of paraffin and intermediate base petroleums.

The *crude gasoline* is sent from the run-down tank to an agitator where it is given a treatment with sulphuric acid, washed to eliminate free acid, neutralized with caustic soda, rewashed with water to remove the alkali, and separated.

The treated gasoline is then pumped to a steam still, where it is separated into different market grades. Each grade of finished gasoline has its own peculiar initial and final boiling points, and percentages that come off at intermediate temperatures.



PRODUCTION OF PETROLEUM IN DIFFERENT COUNTRIES (FROM DATA SUPPLIED BY U. S. BUREAU OF MINES)

The *crude illuminating distillate* passes first to a steam still where the gasoline contained in it is recovered as a distillate and goes to the gasoline agitator for treatment. The illuminating oil passes from the still to the agitator, where it is given a treatment with acid and alkali and washed in the same manner as was done with the gasoline. Air under pressure is used as a means of agitation. The treated illuminating oil is next pumped to a Fullers earth filter, where it is filtered to practically water-white color. From the filter the illuminating oil or kerosene passes to a large open top storage tank enclosed within a building, where any earth remaining in it is allowed to settle. From the settling tanks it is pumped to the finished illuminating oil tanks. Illuminating oils are all run to a certain flash test, prescribed by law in different

states and countries.

The *lubricating distillate* passes to a combined steam and fire still where its temperature is raised sufficiently high to "crack" or crystalize the amorphous paraffin wax it contains. Only crystalline wax can be properly separated from the oil by pressing. Some *fuel oil* is usually separated as an overhead distillate at this stage. The lubricating distillate then passes from the still to an agitator, where it is given an acid and alkali treatment and thoroughly washed with water. From the agitator it goes through a series of water-cooled chillers; next through a series of freezing chillers. At the end of the chilling operation the consistency of the distillate has been increased to about that of a medium cup grease, owing to the crystalization of the paraffin wax content. The chilled distillate is next forced into a wax press, when the oil passes through the canvas and the separated wax remains behind in the press.

The pressed lubricating distillate is pumped to a steam and fire reducing still, where it is separated into *fuel oil* and into light and heavy unfiltered lubricating oils. There are two methods of making this separation. In the first case the fuel oil, and the light and heavy lubricating oils can be separated in the form of distillates. In the second case the fuel oil and light lubricating oil can be separated as distillates, and the heavy lubricating oil left in the still as a residuum. After separation the light and heavy lubricating oils are filtered until the colors are standard, and are then pumped to finished lubricating oil tanks. During the filtration, the light and heavy lubricating oils can each be separated into a large number of oils of different colors, ranging from nearly water-white to deep reds by transmitted light. The process of filtration offers to a somewhat less degree a ready means of fractionating lubricating oils into groups differing widely as to viscosity and other physical properties. High grade automobile oils produced from paraffin or intermediate base crudes are made from the so-called spindle oils, or from filtered spindle oils blended with filtered low cold-test cylinder stock.

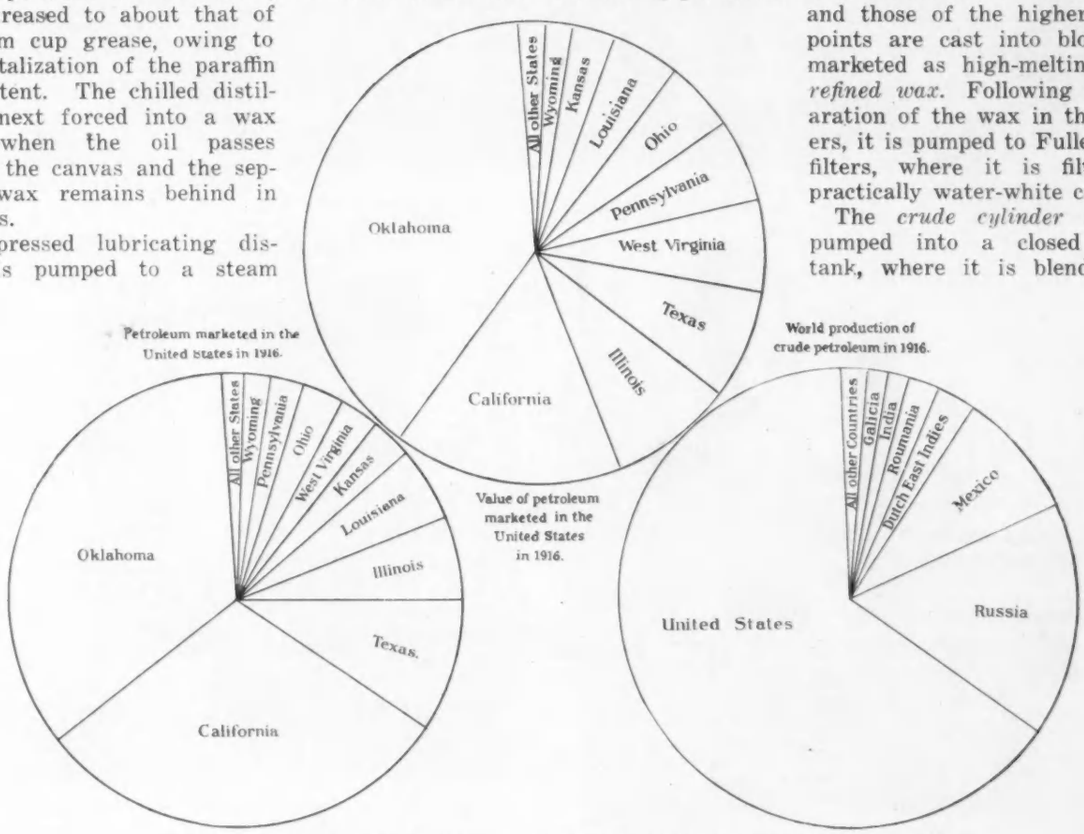
The *paraffin wax* (slack wax) is removed from the press, melted and pumped to the sweater pans, where all but a small portion of the oil remaining in it is eliminated by sweating. This oil (foots), still containing a fair amount of dissolved wax, is returned to the chillers; here it is blended with new lubricating distillate and passes through the chilling and pressing operations a second time. After the first separation the wax recovered can be resweated and thus separated into grades having different boiling points.

The boiling point of the wax is largely determined by the percentage of oil contained in it. Waxes of relatively low boiling points are marketed in the form of *scale wax* and those of the higher boiling points are cast into blocks and marketed as high-melting point, *refined wax*. Following the separation of the wax in the sweaters, it is pumped to Fullers earth filters, where it is filtered to practically water-white color.

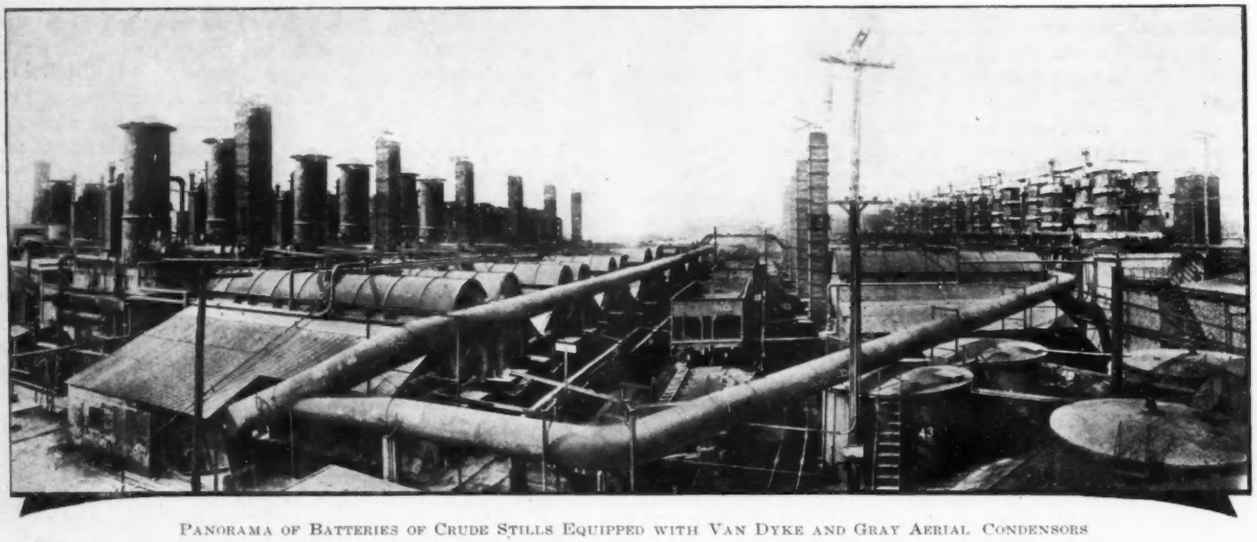
The *crude cylinder stock* is pumped into a closed mixing tank, where it is blended with a special naphtha to thin it down sufficiently to permit the separation of petrola (vaseline) from it and of easy filtration. It is necessary to remove the amorphous paraffin wax from cylinder stocks in order to lower their chill point. The cylinder stock-naphtha solution then passes on to a chiller, where its temperature is reduced to such an extent as to cause a precipitation of practically all of the amorphous paraffin wax contained in it. The clear supernatant solution is then decanted and pumped to a Fullers earth filter.

The filtered cylinder stock solution is sent to a steam still, where the blending naphtha is recovered as a distillate, being returned to the blending tank ready for the next charge. The cylinder stock remaining in the still is then pumped to an open top tank, where it is blown with air to remove all traces of water, which may be present. After this dehydration the cylinder stock is pumped to the finished tanks.

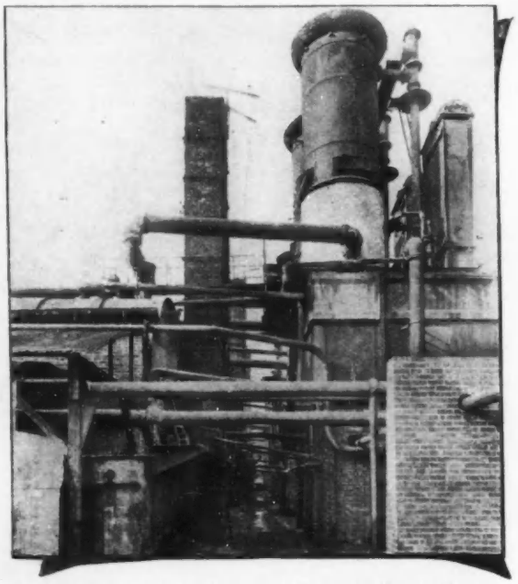
The *petrola* settled out of the cylinder stock solution in the chilling tank is sent to the blending tank and mixed with more naphtha to reduce its viscosity sufficient to



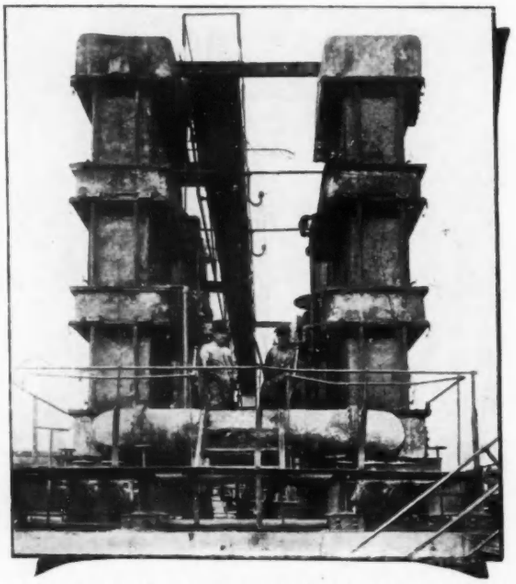
CHARTS FROM "PETROLEUM IN 1916," BY JOHN D. NORTHROP, U. S. GEOL. SURVEY



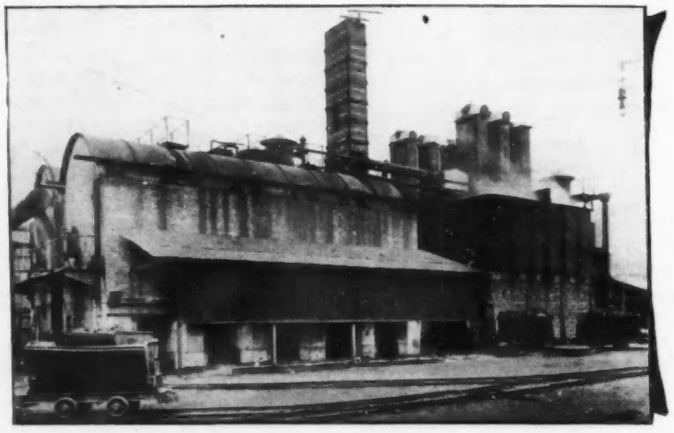
PANORAMA OF BATTERIES OF CRUDE STILLS EQUIPPED WITH VAN DYKE AND GRAY AERIAL CONDENSORS



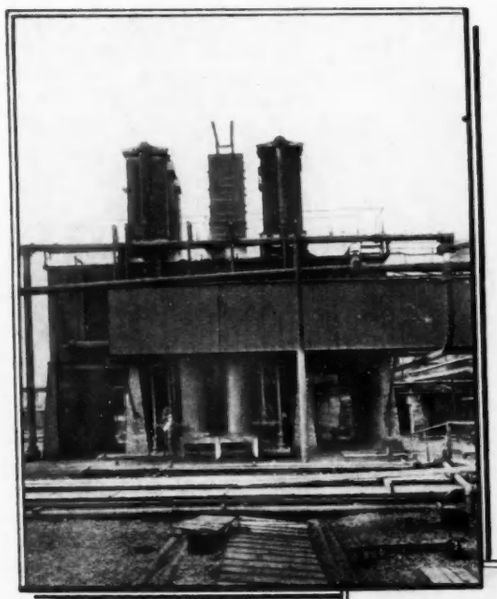
VAN DYKE AERIAL CONDENSORS AND FLUE END OF CRUDE STILLS. INDUSTRIAL RAILWAY TO REMOVE STILL COKE SEEN BETWEEN THE TWO



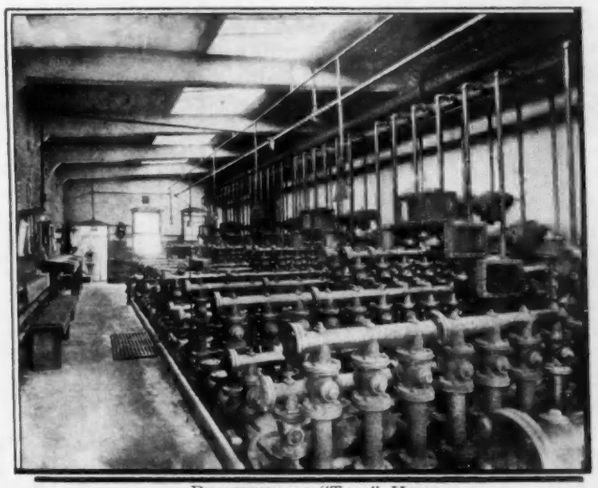
GRAY AERIAL CONDENSORS AND TOP OF WATER-COOLED CONDENSOR BOX



SIDE VIEW OF RECENT TYPE OF CRUDE STILLS
Shows fire doors for firing, forced draft system, removal of still coke on industrial cars, aerial condensers and water-cooled condenser boxes

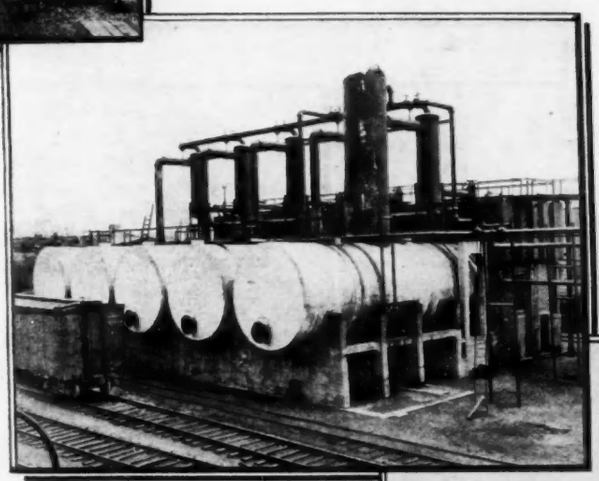


RECENT TYPE OF CRUDE STILLS SHOWING ARRANGEMENT OF AERIAL AND WATER-COOLED CONDENSER AND OIL SEPARATORS



RECEIVING OR "TAIL" HOUSE

Distillates coming from the crude stills via aerial and water-cooled condensors enter tail house, where the gas is trapped off the streams which flow into "look" boxes. The look boxes are arranged on manifolds connecting with different "run-down" tanks

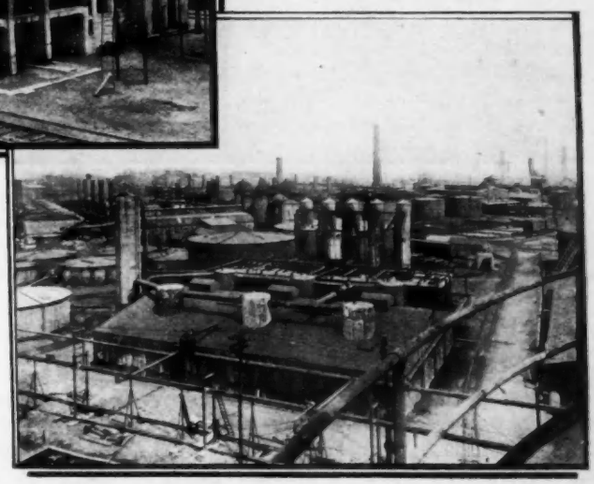


CONDENSOR END OF CONTINUOUS STEAM STILLS (BELOW)

Shows water-cooled condensor box, separators and stream lines leading from separators to tail house

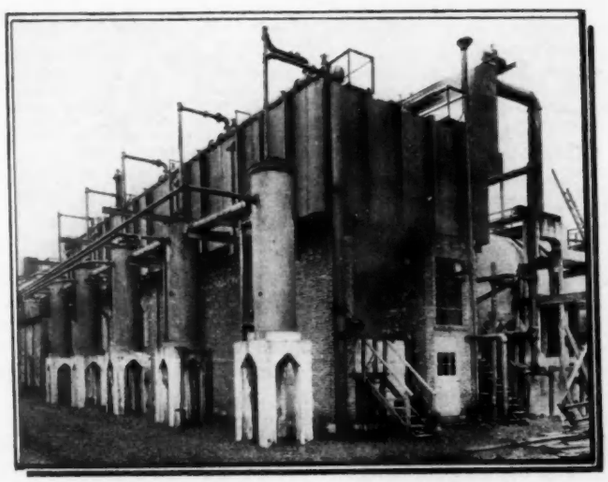
CONTINUOUS STEAM STILLS

Used for separating treated gasoline distillates into finished market grades. This type of still is also used for recovering blending naptha from filtered cylinder stock or petrola (vaseline) solutions and for the fractionation of other light oils



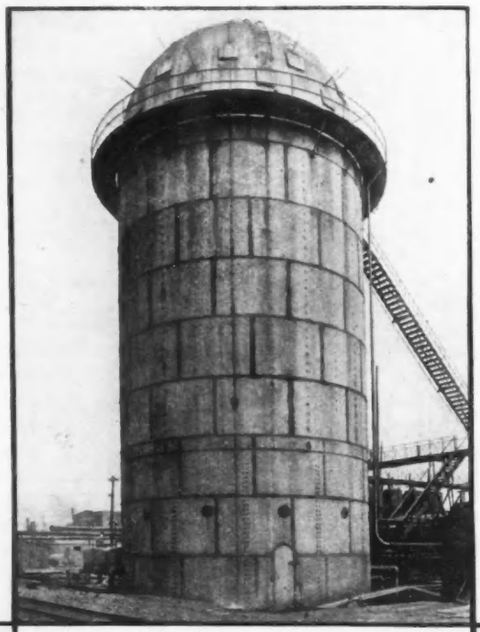
CONTINUOUS STEAM STILL FOR RECOVERING GASOLINE FROM THE ILLUMINATING OIL DISTILLATE

Shows still heads, condensing towers, water-cooled condensors and oil separators



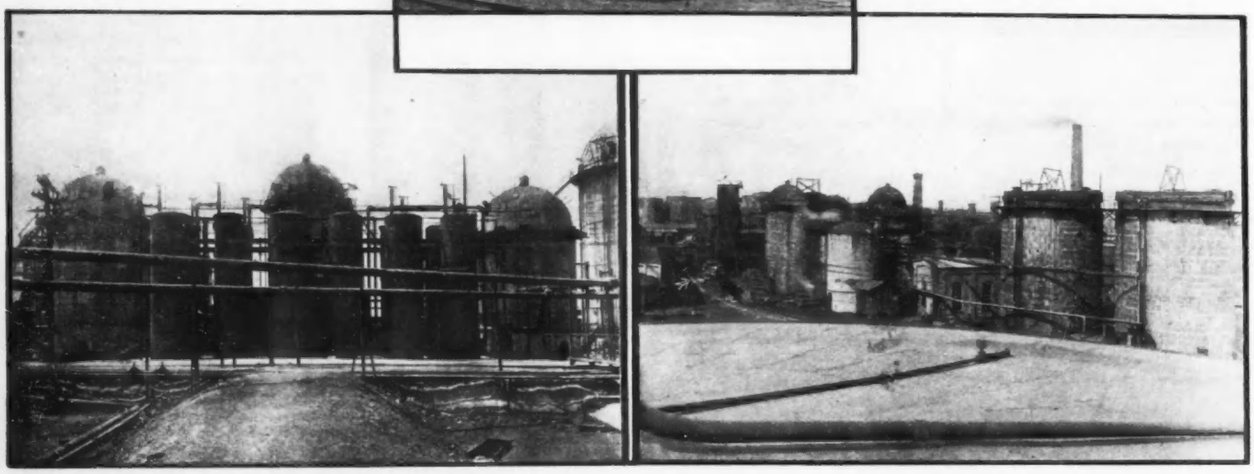
permit easy filtration. From the blending tank the petrola passes on to a Fullers earth or animal charcoal filter and thence to a steam still, where the blending naphtha is recovered as a distillate and returned to the blending tank. The filtered petrola remains behind as a residuum in the still and is pumped from there to the finished tanks. As an intermediate stage in the refining of petrola, after the second blending with naphtha these solutions can be repeatedly chilled and petrola separated out. Each of such successive chillings and separations reduces the oil content and improves the purity of the petrola or amorphous paraffin wax.

The production of gasoline from heavy non-volatile oils has attained a position of such importance in the refining of petroleum, as now to represent almost an industry in itself. It is customary to use the gas oils recovered from various reducing stills about the refinery as charging oil for the cracking stills. Prior to the development and commercialization of well-known cracking processes, oil refiners were well aware of the fact that decomposition took place at a certain stage in the destructive distillation of petroleum by fire in ordinary stills at atmospheric pressure. At an early date in the art, it was found that the percentage of the light volatile distillates recoverable from a given petroleum could be greatly increased by destructive distillation, whereas by distillation under vacuum or with steam the yield of these products was greatly reduced. Briefly stated, the mechanism of cracking consists substantially in subjecting hydrocarbons of high molecular weight to relatively high pressures and temperatures, which cause their decomposition into hydrocarbons having increased volatility and lower molecular weight.



FIVE THOUSAND BARREL ILLUMINATING OIL AGITATOR

The charge of crude kerosene is chemically treated and thoroughly washed with water, air being used to "agitate" the oil during treatment



BATTERY OF AGITATORS FOR TREATING GASOLINE CONTINUOUSLY

The crude gasoline passes successively through all of the twelve cylindrical tanks seen in the foreground where it is chemically treated and thoroughly washed. The kerosene agitators are seen in the background

LUBRICATING OIL AGITATORS

The distillate from which lubricating oil is made is chemically treated and thoroughly washed with water in these agitators, which are insulated against heat radiation. All distillates are treated with concentrated sulphuric acid to remove color bearing and other undesirable compounds. Treatment is made with caustic alkalies chiefly for the purpose of neutralization

Finished Products

Some of the finished lubricating distillates, after passing through the filters, do not conform to standard market specifications. In order to convert them into market grades it is necessary therefore to blend them properly into final market form.

As applied to lubricating oils, the lists prepared by refiners of Pennsylvania and intermediate base petroleums are roughly divided into different groups, namely: "paraffin" oils, wool stock, white neutral oils, filtered spindles, unfiltered and filtered cylinder stocks and black oils. The word "paraffin" so used has no reference to the base of the crude petroleum from which it has been made. All oils classified as "paraffin" oils, by reason of their peculiar manufacture, still contain compounds that readily decompose when subjected to heat. The light color of pale paraffin oils has been attained by the heavy treatment of "paraffin" lubricating distillates with sulphuric acid. These oils almost invariably contain sulpho compounds. The red paraffin oils may or may not have received the sulphuric acid treatment but they also contain compounds readily decomposed by heat. Oils belonging to this "paraffin" group are not suitable for use in internal combustion engines, in which they quickly lose their lubricating properties.

Wool stock is made by exposing different oils to the action of the ultra-violet rays of direct sunlight to increase

their emulsifying properties. They are not intended for lubrication of machines.

The white neutral oils are all filtered and represent the "head" end of spindle oils, that is, the first white oil coming through when pressed lubricating distillates are filtered.

The yellow filtered spindle oils represent the major portion of the oil coming through the filters.

The red filtered spindle oils contain more coloring matter than do the yellow, because of the fact that as filtration proceeds the Fullers earth becomes charged more and more with color-bearing compounds. Red spindles represent the tail end of the filtrate.

The quality of cylinder stocks is dependent upon the characteristics of the crude petroleum from which it is made. The best cylinder stocks are made from petroleums containing the greatest amount of hydrocarbons belonging to the paraffin series, and the poorest from petroleums containing a reduced quantity of paraffins and an increased quantity of asphaltic compounds. The difference between the filtered and unfiltered cylinder stocks made from the same residuum is measured by the degree of filtration to which they have been subjected.

The black oils are usually made from still bottoms, where a reduced quantity of steam has been used during the distillation.

Refinery By-products

The principal by-products from the refining of petroleum consist of *still coke*, remaining as a residue from destructive distillation; *wax tailings* that come over near the end of a destructive distillation just before the still is "coked," and *acid cake*, made up of the solids separated from the many distillates by their treatment with sulphuric acid. Still coke is used in the manufacture of electric-light carbons and abrasives. Wax tailings are used as a waterproofing compound. Acid cake is converted into many grades of insulating and roofing pitches.

Thickened Oils—Greases

Very little information has been given out by manufacturers concerning transmission lubricants. In order to understand intelligently of what they consist, a description of their manufacture appears necessary. In all types of greases, from fluid to solid, the lubricating properties are entirely determined by the lubricating properties of the unsaponified oils and hydrocarbon oils contained in them. The question at once arises as to the need of manufacturing any greases at all. The reason is that no satisfactory commercial lubricants of hydrocarbon or fatty oil origin are sufficiently thick or have the characteristics required for the lubrication of all types of transmissions, hence it has been necessary to find a means of artificially thickening available oils to the desired degree. Various classes of grease (thickened oils) are manufactured to meet this need.

All greases contain a soap portion, which has the remarkable property of acting as a sponge for the absorption of hydrocarbon oils to such an extent as to completely hide the presence of these oils. The character of the grease is determined by the sort of fatty oil (animal or vegetable) and the nature of the agent—calcium, potassium, sodium or lead—used in their saponification. After the soap has been made, the hydrocarbon oil is gradually stirred into it at the proper time. When cooled, the soap and oil, thus mixed, are found to have produced a grease. The thickness of the grease is determined by the quantity and viscosity of the hydrocarbon oil added to the soap.

Most trade-marked greases are characteristically scented to hide the odor of fatty oils or pitches with which they are made, and also to furnish the trade an easy means of identifying different brands of grease by the sense of smell.

Greases may be dyed to give the desired tint, or the color can be determined by that of the hydrocarbon oil used. For instance, very heavy, dark-colored, semi-fluid greases (gear compounds) are made by blending anhydrous greases with heavy residuual cylinder stocks, asphaltic oils or tars.

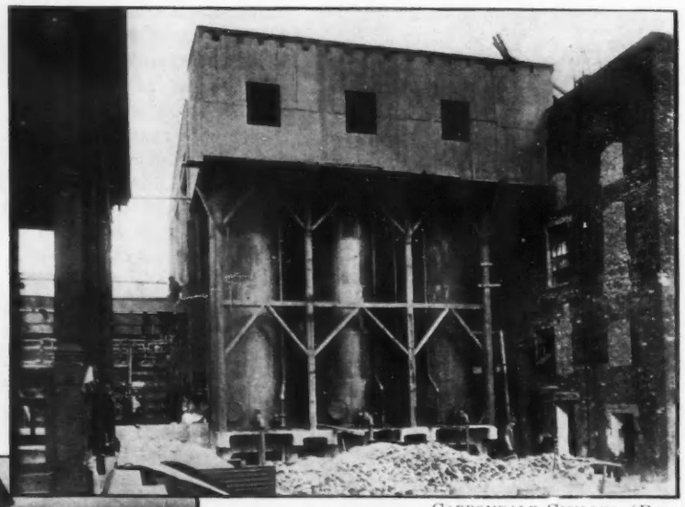
The surface of greases in different containers often undergoes a change in color because of free exposure to the air. This is noticed at once when the surface grease is removed. Such discoloration is due to a very slight oxidation, which penetrates the grease to a slight depth, but in no way affects its quality.

Greases may be anhydrous, or contain variable quantities of water. Anhydrous greases have the property of not suffering separation of their constituents when repeatedly heated and cooled. The reverse is true of cup greases, which contain a fair percentage of water, and which separate permanently on heating. Between the extremes of cup greases and sponge greases lie those (fluid or semi-fluid) which contain a small amount of water and a large percentage of hydrocarbon oils, but which do not separate on repeated heating and cooling. Cup greases, semi-fluid oils and fiber greases readily combine with water, and should be used only when moisture is not present. On the contrary, lead soap greases do not emulsify with water.

The quality of greases cannot always be judged by their appearance. Some manufacturers employ cheap gas oil and other light non-lubricating oils in the blending, and use more soap or filler to secure the desired consistency. The finished greases made in this manner have but little lubricating value. Manufacturers working under misconceptions of the lubrication requirements of transmissions, produce and sell cup and fiber greases mixed with wood-fiber, asbestos, talc, and similar adulterants, and advertise their products as a sure cure for noisy gears.

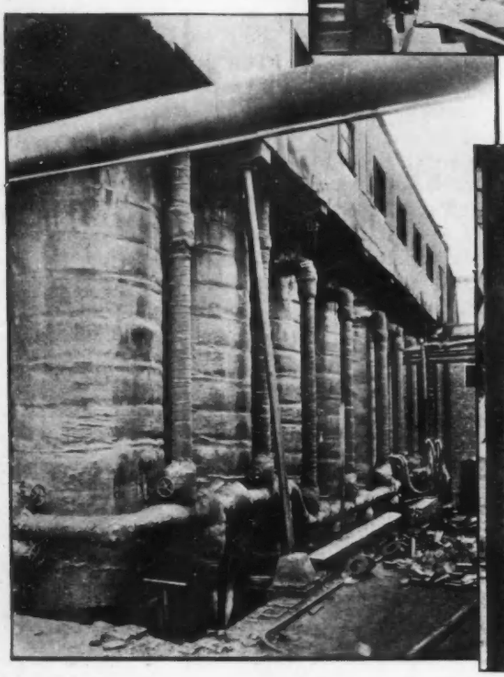
All greases containing such adulterants are to be avoided, as their application cannot fail to result in a material power-transmission loss and in the destructive effects of insufficient lubrication. Inferior grades of gear compounds are sometimes made from a mixture of paraffin wax or solid residuals and tars blended with heavy oils; but inasmuch as paraffin wax and tar have practically no lubricating properties, such mixtures are to be scrupulously avoided. On account of the present high cost of the constituents of lubricating greases there is now a tendency to lower their quality by the substitution of less costly fatty oils, as well as low-grade or non-viscous hydrocarbon oils.

Author's Note.—In the preparation of this paper it has naturally been necessary for me to seek aid from many different sources. I therefore wish to express my sincere appreciation for the valuable cooperation of the Bureau of Mines, of the Delco Company, of several of the officers of the Society, and of the Tide Water Oil Company. The last company has been kind enough to contribute unrestricted use of its laboratories and personnel and to grant me full access to any and all of its processing records; it has also permitted me to make photographs of typical refinery equipment. S. E. Campbell, chief chemist of the Tide Water Company, in particular, rendered most valuable assistance in collecting the various samples and apparatus used.



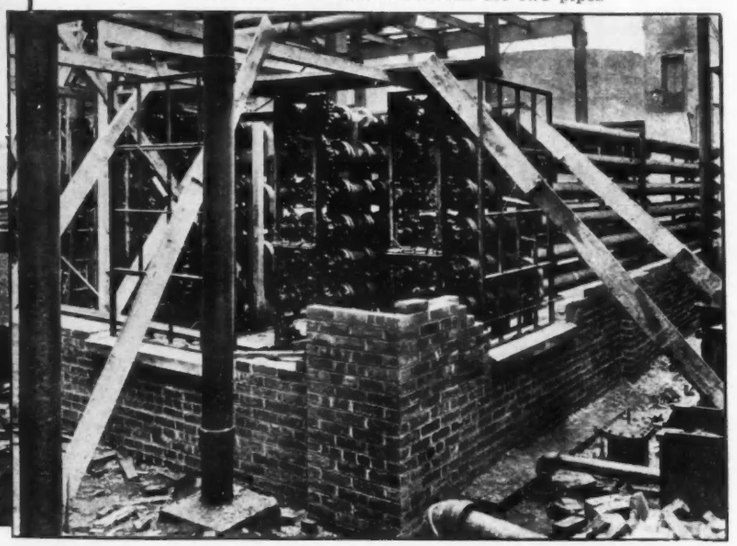
WATER-COOLED CHILLERS

Here the lubricating distillate first begins to lose its heat before passing on to calcium chloride chillers



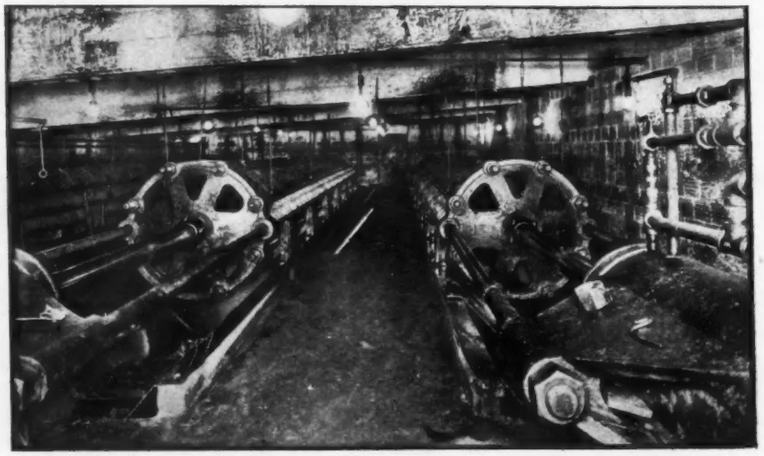
CARBONDALE CHILLER (BELOW)

In this the distillate is forced by a screw to pass successively through a series of pipes. Concentric to the inner pipe through which the distillate passes an outer pipe is arranged. The "brine" or chilling solution is circulated between the two pipes



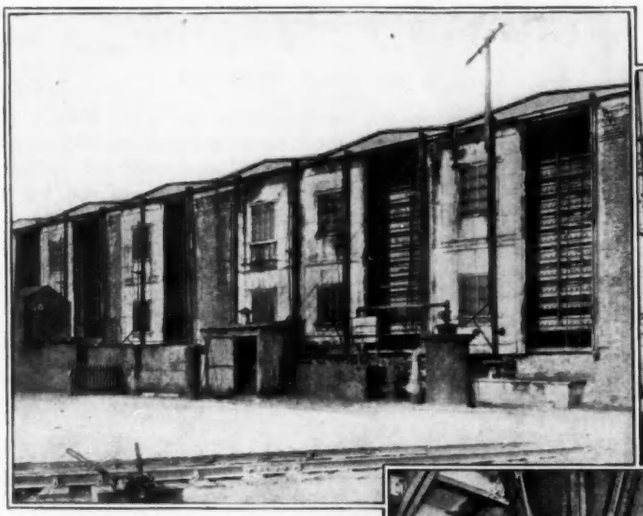
GRAY CHILLERS (ABOVE)

The construction of these chillers closely resembles that of an ordinary ice cream freezer, except that the outer walls are double and a "brine" (calcium chloride) freezing solution is circulated in the space between the walls. The lubricating distillate containing paraffin wax passes successively from one chiller to another, being brought into intimate contact with the chilled inner wall by rotating paddles until the wax is crystallized and the temperature of the whole has dropped to about 20 deg. fahr.



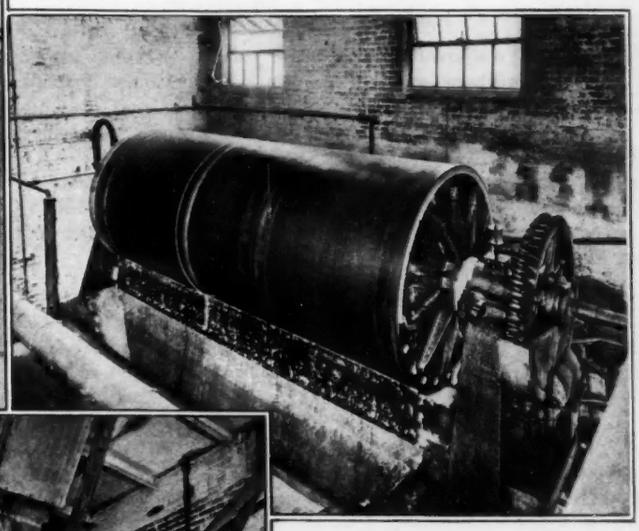
WAX PRESSES

These consist of about 500 plates between which is interposed heavy filter canvas. The chilled lubricating distillate is forced into the center of these presses. The oil filters through the canvas and the crystalline paraffin wax remains behind. When the pressure on the distillate attains abut 350 lb. per sq. in. the press "goes dry," that is, no more oil will pass through. The presses are next opened up and the cakes of "slack" paraffin wax between the plates are removed



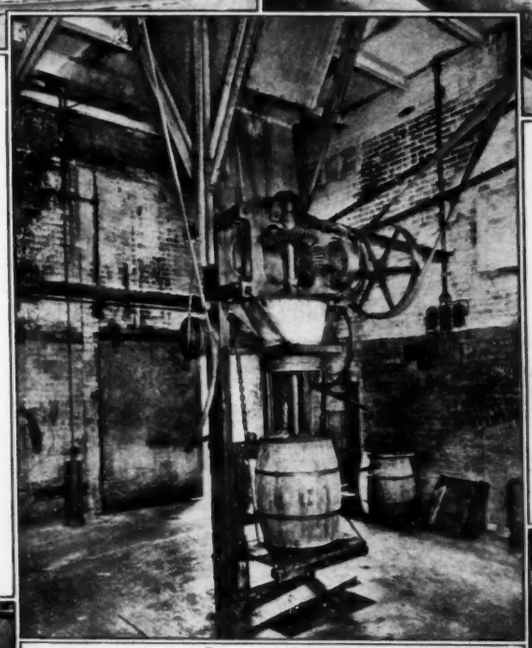
BATTERY OF WAX SWEATERS

The molten slack wax is flowed into the sweater pans on top of water, with which each pan is half filled. The wax is next chilled until solid and the water allowed to escape from beneath. The sweater house is then closed and the temperature of each room is rapidly raised. As the temperature of the slack wax rises, the oil contained in it first melts and flows out leaving the wax behind. Gradual increase in temperature from this point on results in the fractionation of paraffin waxes having different melting points. This process is simply the reversal of fractional crystallization



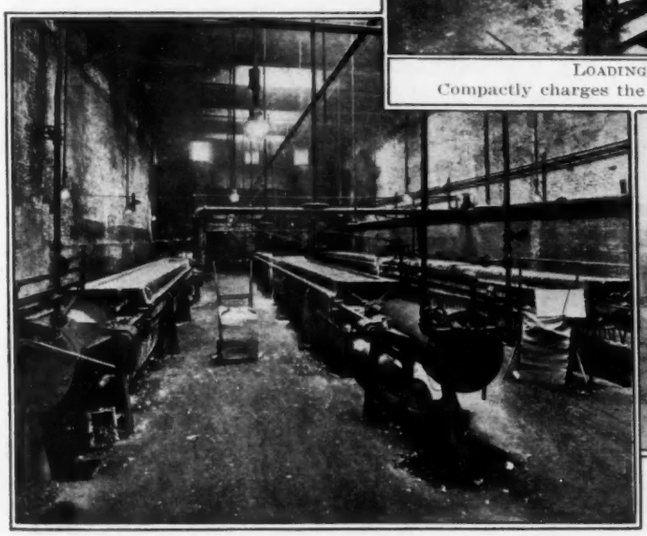
SCALE WAX MACHINE

As the water-cooled cylinder which dips into a pan of molten wax is revolved a certain amount of wax adheres to it, is solidified and is scraped or "scaled" off into the hopper leading to the mechanical barrel filler below



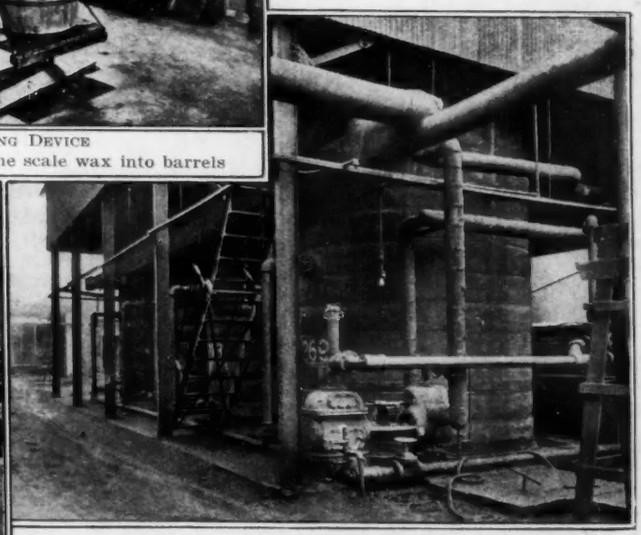
LOADING DEVICE

Compactly charges the scale wax into barrels



WATER-COOLED MOLDING MACHINE

In this the refined paraffin wax is molded



CYLINDER STOCK SOLUTION CHILLERS

In these tanks a solution of cylinder stock and blending naptha is chilled to about 20 deg. fahr. for the purpose of settling out the petrola (amorphous paraffin wax). The freezing brine is circulated through a series of closed coils immersed in the solution

Demonstrations of Refining

The demonstrations given when the above paper was presented at the Dayton meeting are described very briefly in the following paragraphs.

Fractional Distillation

Object.—To show that crude petroleum is made up of a complex mixture of hydrocarbons, which may be separated by distillation.

Method.—Destructive distillation of Pennsylvania petroleum into three fractions: (1) Crude gasoline, (2) crude kerosene, and (3) paraffin lubricating distillate. Still residue, coke. Chilling of crude lubricating distillate caused its solidification, thus showing the presence of paraffin wax.

Clarification and Purification of Distillates

Acid Treatment.—A crude light lubricating distillate, very dark in color, was treated with concentrated 66-deg. sulphuric acid, separated, washed with water, then treated with caustic soda to neutralize, separated, and washed with water. The color of the oil was thus changed from dark brown to light reddish yellow by transmitted light.

Percolation Through Fullers Earth.—A dark brown crude Pennsylvania petroleum was percolated through a double filter containing Fullers earth. The first four ounces coming through were water white. As the percolation proceeded the filtrate began to show color, first pale lemon, gradually shading into a deep yellow.

Fractional Distillation of Finished Lubricating Oils

Object.—To show that finished light-colored lubricating oils intended for automobile engines still consist of a complex mixture of hydrocarbons, which differ materially in their physical and chemical characteristics.

Method.—Samples were shown of a light-colored lubricating oil fractionated into nine distillates under a high vacuum, and a tenth sample representing the residual left in the still at the end of the distillation. The first tenth cut was an oil of low viscosity and very light color. Passing from the first cut to the ninth, the viscosity of the fractions rapidly increased and the shading of color passed from light lemon yellow to deep red by transmitted light. The residuum closely resembles a dark green viscous cylinder stock.

Discoloration of Oils by Heat

Two fresh samples similar in color (pale yellow) and viscosity, but of different chemical purity, were heated to the same temperature for the same length of time. The sample containing impurities almost immediately turned to a jet black, while that which had been thoroughly purified only showed a slight deepening in color.

Dehydration

A finished engine oil, cloudy to the point of being opaque because of the presence of water, was slightly heated and blown with air. In a few minutes all moisture was removed and the oil was completely clarified.

Effect of Temperature on Consistency of Hydrocarbons

It was planned to completely solidify a sample of light aviation gasoline in liquid air. Solidification occurs at about — 110 deg. cent. The gasoline again becomes fluid at about — 90 deg. cent. Intermediate between the solid and liquid states the gasoline becomes semi-fluid, and closely resembles ordinary white vaseline.

Difference in Volatility of Crude Petroleums

Samples of two crude Pennsylvania petroleums obtained in localities not very distant from each other were exposed to the flame of a match in watch glasses. The volatile sample readily ignited while the less volatile refused to ignite, extinguishing the match when it was plunged into the oil.

Emulsifying Properties

Samples were shown to illustrate the wide difference in emulsifying properties of various finished hydrocarbon oils: (1) A light automobile-engine oil, which showed a perfect interface between the oil and the water on which it floated; (2) an acid-treated "paraffin" oil, which showed a permanent emulsification of a portion of the oil with the water, the water under the emulsion was opaque and milky; (3) an acid-treated "paraffin" oil (wool oil) which had been exposed to the ultra-violet rays of direct sunlight, causing its complete and permanent emulsification with water.

Distinguishing Between Paraffin and Asphaltic Base Oils

Samples of refined engine oils made from paraffin and asphaltic base crudes were exposed in 4-oz. bottles to the ultra-violet rays given off by an exposed arc. The florescence shown by the paraffin base oil was deep violet while that of the asphaltic base oil was a light robin's-egg blue.

Thickened Oils—Greases

1. A cold-set axle grease was made by stirring powdered calcium hydrate with kidney oil and a high percentage of a light hydrocarbon oil.
2. A locomotive driving axle grease was made by stirring a large percentage of ordinary green cylinder stock with sodium hydrate and a fatty oil. This grease was about as hard as ordinary laundry soap when finished.
3. A sample of ordinary cup grease was heated to about the temperature of boiling water for a short time, causing the permanent separation of the hydrocarbon oil contained in it from the soap "sponge."
4. A sample of anhydrous grease was heated in the same way as was the cup grease. This grease became fluid, but upon cooling regained its former consistency without separation of its constituents.

List of Samples

The following samples were exhibited at the same time that the demonstrations were made. These embrace practically all products made from paraffin and intermediate base petroleums by destructive distillation and by distillation with steam.

Crude Petroleums

1. Volatile and non-volatile Pennsylvania crudes.
2. Mid-continent.
3. Gulf Coast.
4. California viscous.
5. Mexican black, very viscous.
6. Utah shale.

Gasolines

1. Still gas naphtha, low and high pressure condensates.
2. Several crude naphtha distillates.
3. Several finished gasolines—aero, auto, cleaning, blending and petroleum ether.

Kerosenes

1. Crude illuminating distillates, water white, standard white, petrolite and test petrolite.
2. Finished water white, standard white and petrolite kerosene.

Gas Oils

Several gas oils—refinery, steam still, test, pressure still and light and heavy from the lubricating oil reducing stills.

BATTERY OF FULLERS EARTH FILTERS UNDER CONSTRUCTION
Each filter consists of a tapered steel cylinder about 16 ft. high. The filters are slightly tapered to prevent "channelling" of the earth when the oil passes through

Lubricating Oils

1. Samples of crude lubricating distillates made by destructive and by steam distillation.
2. Samples of same distillates treated.
3. Samples of same distillates pressed.
4. Samples of yellow acid-treated "paraffin" oils—light to heavy grades.

TOP VIEW OF A BATTERY OF OIL FILTERS
Shows the filter caps projecting above the floor, pressure gages and feeding manifolds attached to each. The Fullers earth can be seen on its way via the belt conveyor to the filter, which is being automatically charged

5. Samples of red acid-treated "paraffin" oils, light to heavy grades.
6. Samples of reduced spindle oils—light to heavy grades.
7. Samples of filtered white, yellow and red spindle oils —light to heavy grades.
8. Samples of spindle oils blended with low cold-test filtered cylinder stock—heavy and extra heavy grades.
9. Samples of special low cold test ice machine oil.
10. Samples of acid-treated emulsifying wool oils.

Paraffin Wax

1. Sample of "foots" oil.
2. Sample of treated slack wax.
3. Samples of finished filtered paraffin wax of different melting points.

Cylinder Stocks

1. Several grades of crude cylinder stocks.
2. Samples of filtered high cold-test cylinder stocks.
3. Samples of filtered low cold-test cylinder stocks.
4. Samples of strained dark colored cylinder stocks.

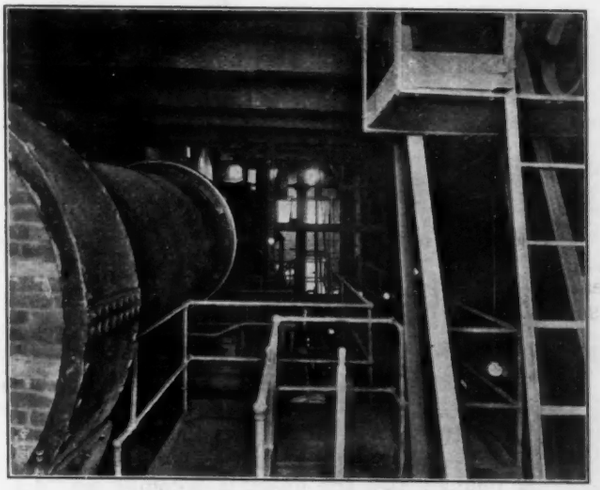
Crude Still End Products

1. Gum—wax tailings.
2. Still bottoms—heavy black oils.
3. Still coke.

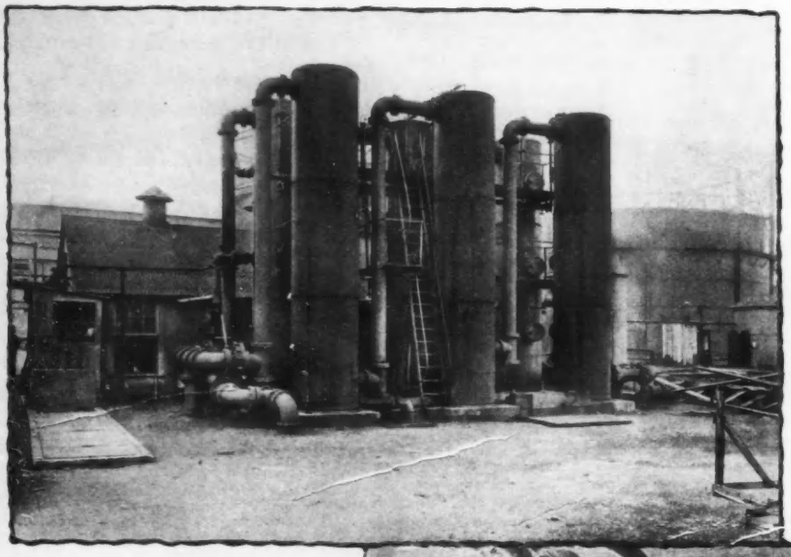
PERSPECTIVE OF NEW FILTER HOUSE
Outside view of a battery of Fullers earth filters. The running tanks from the filters are arranged in the shed seen on the right

Refinery By-Products

1. Fuel oils.
2. Acid oil.
3. Acid cake.
4. Pitches—liquid to solid.



ROTARY FULLERS EARTH RETORT
The used Fullers earth is fed into the upper end of the retort by a continuous belt conveyor. On its passage from the upper end to the lower, all of the color bearing compounds and impurities which the earth has adsorbed from the oil are burned off. From the retort the earth is conveyed through water-cooled rotary coolers and thence back to storage bins, where it is again ready for use



GAS SCRUBBERS

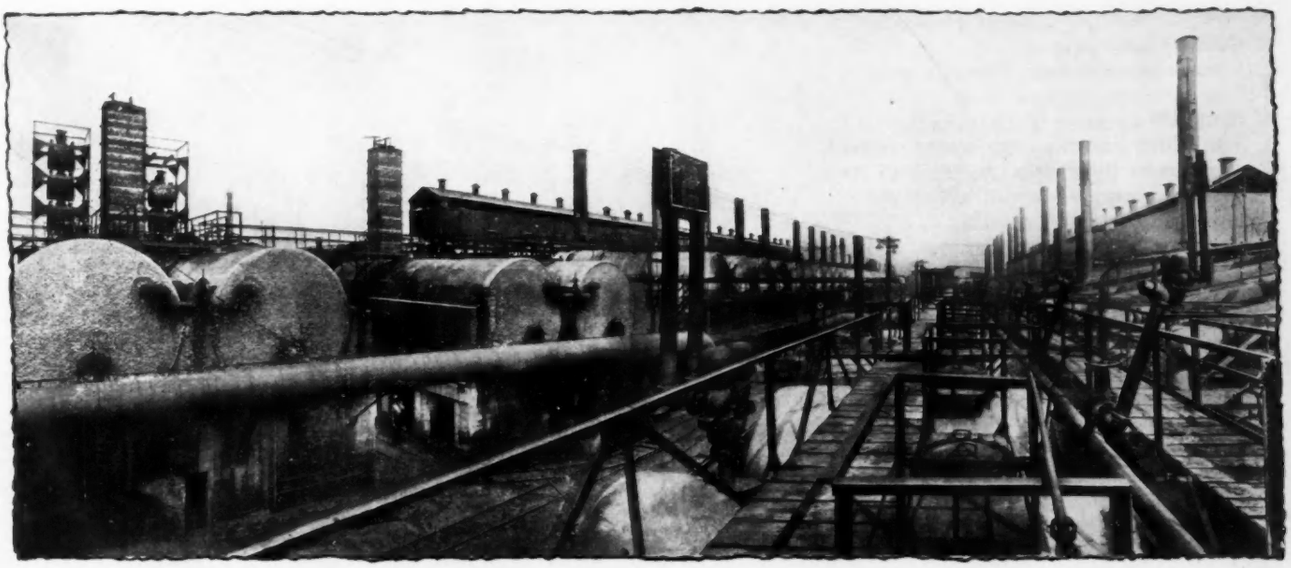
All gas generated in the crude oil and other stills is forced to pass successively through these cylinders, where it is chemically treated and thoroughly washed with water before going to the compressors

HIGH AND LOW PRESSURE GAS COMPRESSORS

The still gases are first compressed to about 45 lb. per sq. in. and cooled. Then further compressed to about 165 lb. per sq. in. and again cooled. From these compressions low and high pressure condensates of light gasoline are obtained. The non-condensable gases are next allowed to bubble through a liquid absorber and then pass on to the gas holder

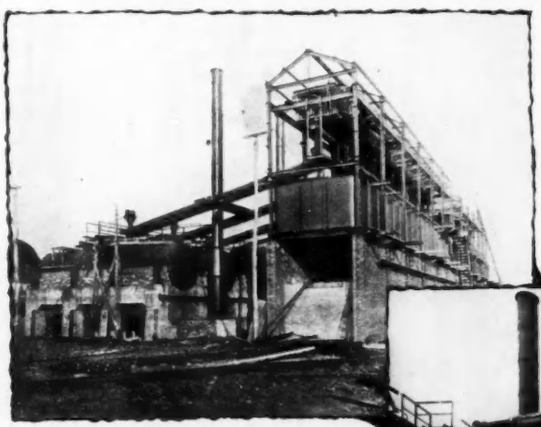
GENERAL VIEW OF STILL GAS COMPRESSOR PLANT

Shows traps, water-cooled condensors, pressure absorbing tanks, atmospheric pressure storage tanks and gas holders



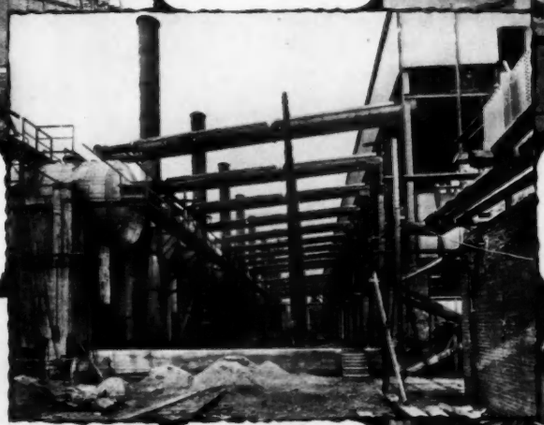
PANORAMA OF BATTERIES OF BURTON CRACKING STILLS

On the right, the tops of shell type stills, the safety valves and charging lines. The battery on the left is of the tubular type, similar in construction to water tube boilers. The four large stills on the extreme left are of the continuous type and are used for separating gasoline from the crude Burton pressure still distillates

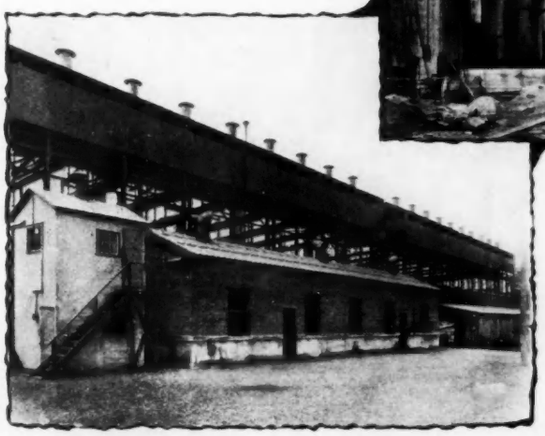


BURTON SHELL TYPE PRESSURE CRACKING STILLS. VAPOR LINES, AERIAL AND WATER-COOLED CONDENSORS UNDER CONSTRUCTION

BATTERIES OF BURTON STILLS. TUBE STILLS, ETC., UNDER CONSTRUCTION IN THE FOREGROUND



STACK END OF BURTON TUBE STILLS, VAPOR LINES AND CONDENSORS



BURTON AERIAL CONDENSORS—TAIL HOUSE IN FOREGROUND

INTERIOR OF TAIL HOUSE ATTACHED TO BURTON STILLS
Shows distillate receiving tanks and individual meters for measuring yields from each still

Special Products

1. Cold set axle greases.
2. Locomotive driving axle solid grease.
3. Cup greases—soft to hard.
4. Graphite greases—soft to hard.
5. Semi-fluid greases (low water content).
6. Anhydrous fiber greases—soft to hard.
7. Gear compounds—semi-fluid.
8. Lead soap grease—semi-fluid.
9. Furniture and floor polishes.

THE DISCUSSION

A MEMBER:—What is the object of cleaning up an oil, that is, of clarifying it?

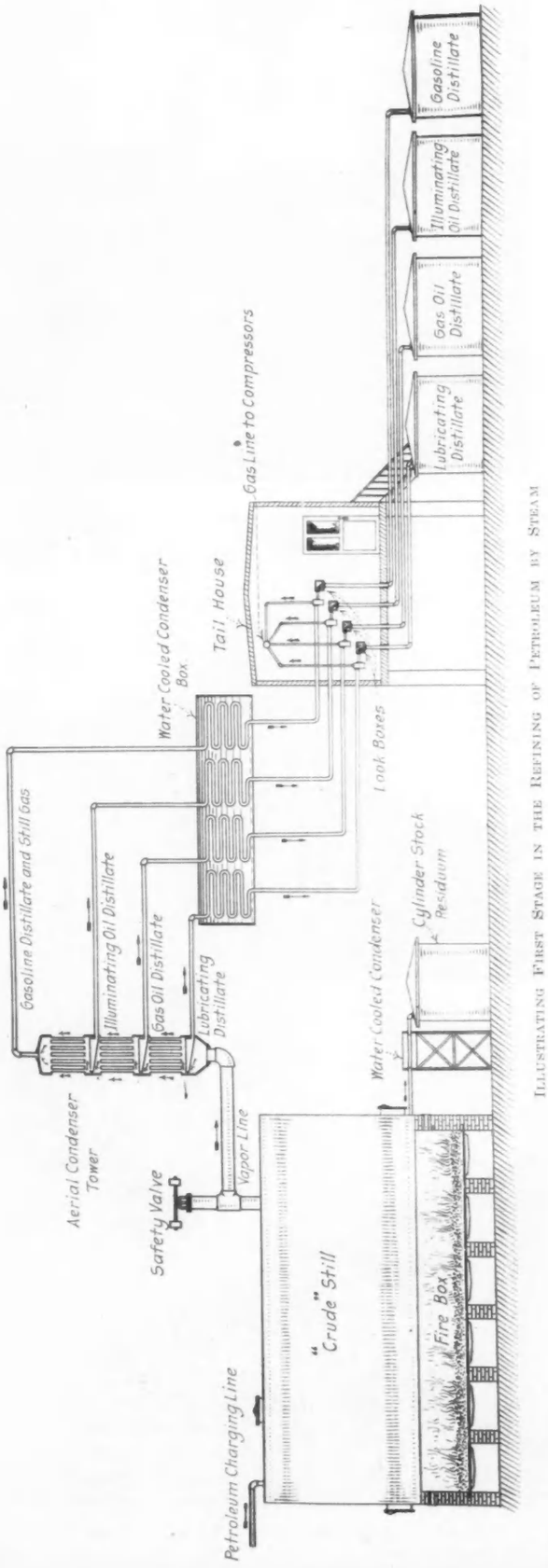
MR. STRATFORD:—The prime object of such cleaning is to remove highly unsaturated, unstable and other undesirable compounds which they contain. Were these compounds allowed to remain in the oil they would rapidly decompose when exposed to heat in a gasoline engine and thus lose their lubricating properties. For the lubrication of other machines that operate at low temperatures it is not so necessary to remove these compounds. Almost without exception, all automobile oils have been given a treatment with sulphuric acid and a final filtering through Fullers earth. This method of processing of good distillates is a guarantee of high heat-resisting properties in the finished oil. Incidentally, the treatment of distillates with sulphuric acid and their filtration clarifies them and makes their color lighter in proportion to the viscosity. In the past certain colors came to be accepted by both refiners and users as representing standard products. The refiners were careful, therefore, in the finishing of their products to bring them up to the accepted color standard. The color, however, of lubricating oils is not necessarily an indication of what will happen to them in service. An old fallacy widely exploited by lubricating oil salesmen was the claim that a light colored oil contained no carbon, while dark colored oils were loaded with it. Erroneous as this statement was, they used the "non-carbon" theory for a great many years. As a matter of fact, the highest grade lubricating oil consists of around 85 per cent of carbon, without which it would cease to exist as an oil.

PRESIDENT KETTERING:—What is the real peculiarity of castor oil as a lubricating oil?

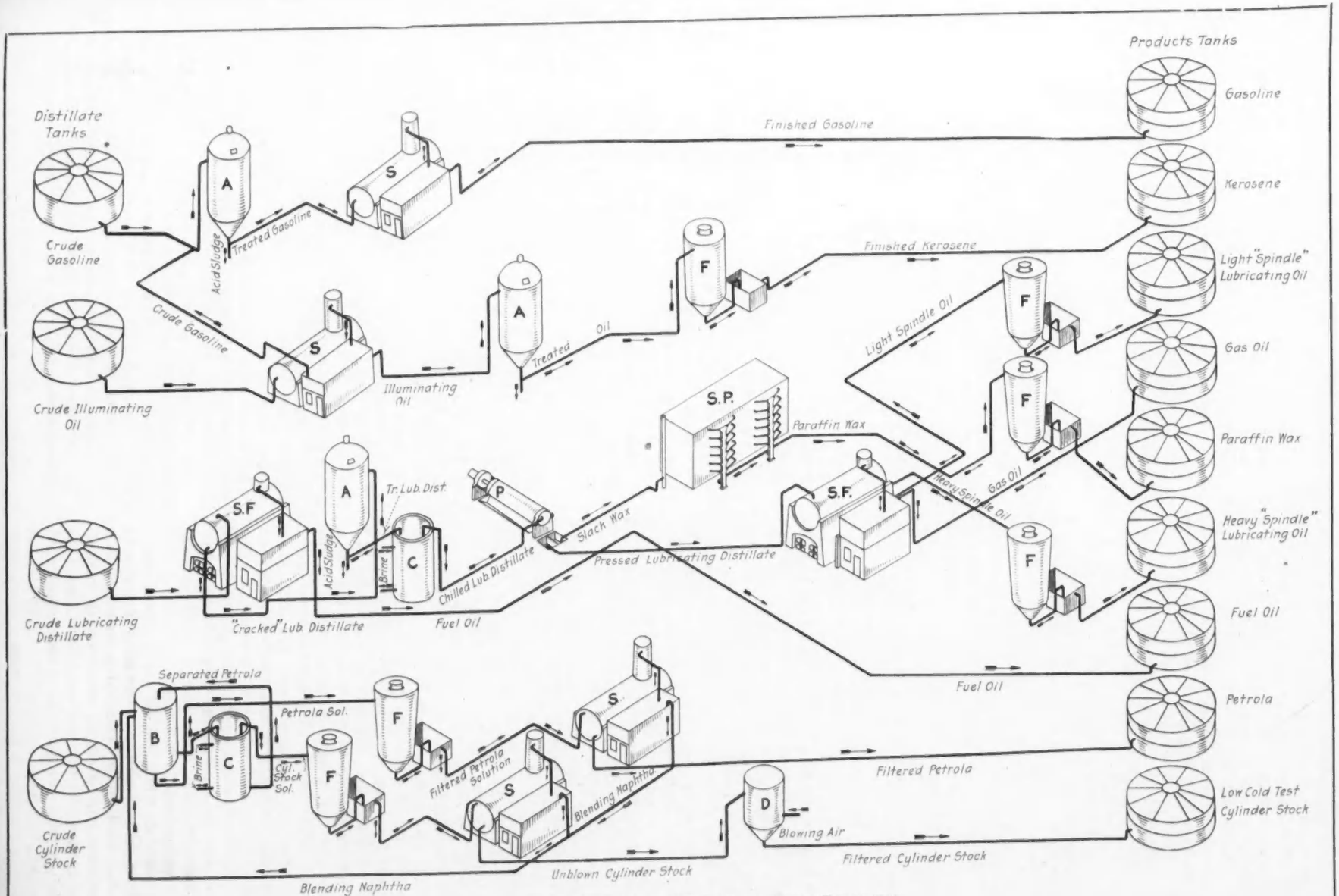
MR. STRATFORD:—Castor oil is a good lubricant.

PRESIDENT KETTERING:—Outside of its being a good lubricant, is there anything in regard to its heat conditions that makes it better than prepared mineral oil for the same service?

MR. STRATFORD:—Nothing will disclose the real lubricating properties of animal and vegetable oils better than the service they give in modern aircraft engines. Most of these engines are equipped with steel cylinders of comparatively thin section. Steel cylinders are more likely to warp than those of cast iron, therefore the lubricating difficulties are increased, since any decided warping will decrease the clearance to such an extent as to cause a heavy metallic contact between the piston and cylinder walls. One fact that is generally recognized by all practical aviation engine men is that castor oil will lubricate the cylinders when all other lubricants fail. At present we do not possess any absolute knowledge as to the whys and wherefores. It may be explained by the fact that castor oil possesses higher adhesive properties than do mineral oils. Certainly, it is not because of any wide difference in viscosity. The curve of the viscosity of castor oil and that of a heavy mineral oil almost coincide throughout the temperature range. Another peculiarity



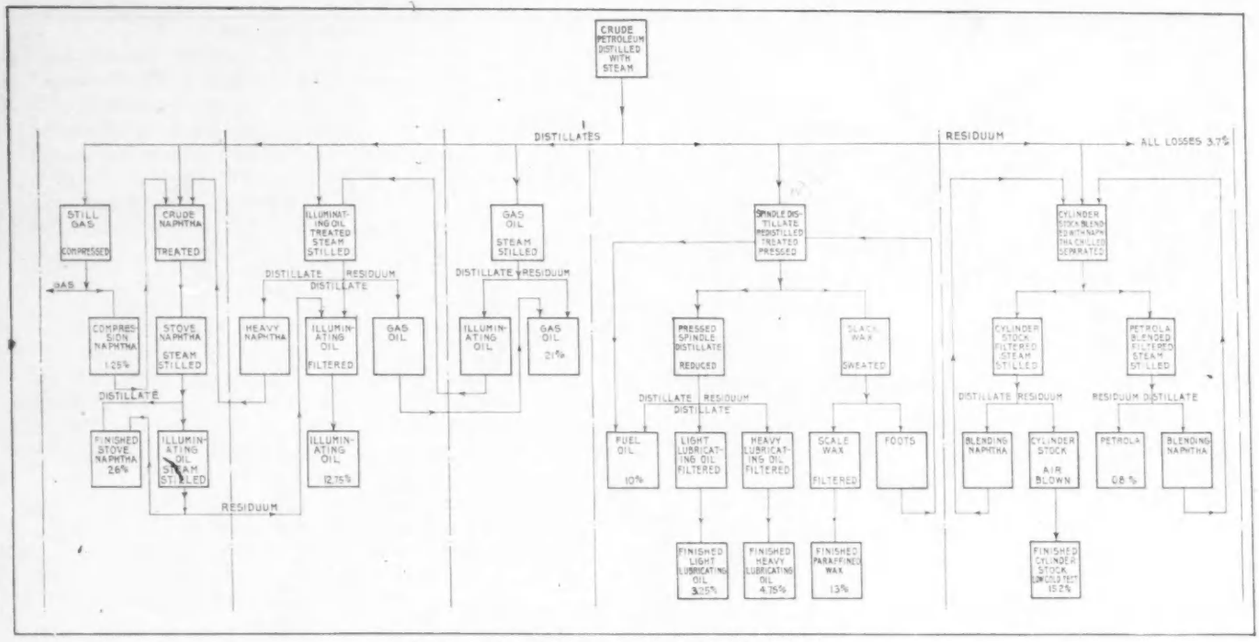
ILLUSTRATING FIRST STAGE IN THE REFINING OF PETROLEUM BY STEAM



FINAL STAGES IN REFINING OF PENNSYLVANIA CRUDE PETROLEUM

KEY TO EQUIPMENT

A—Agitators
B—Blending Tank
C—Chillers
D—Dehydration Tank
F—Filters
P—Wax Press
S—Steam Stills
S.F.—Steam and Fire Stills
S.P.—Wax Sweater Pans



REFINING CHART OF PENNSYLVANIA PETROLEUM

possessed by a castor oil film is that it will thin down but not withdraw from a point of local overheating. Mineral oil films show a tendency to partly or completely withdraw from localized hot spots. Doctor Dickinson of the Bureau of Standards, I believe, has planned some investigation work along these lines to determine the relative adhesive properties of animal, vegetable and mineral oils, also the behavior of their films on unequally heated surfaces. All things considered, castor oil appears to be the ideal lubricant under the most difficult conditions of the lubricating of surfaces operating at high temperatures, such as are found in aviation engines.

In air-cooled engines like the Gnome rotary, where a fuel mixture rich in gasoline is lead to the cylinders through the crankcase, it is imperative to use only castor oil for the lubrication of the parts, owing to the fact that castor oil is practically insoluble in all grades of gasoline. The insolubility of castor oil in fuel mixtures prevents contamination of the oil in the crankcase of aviation engines of all types and the oil therefore retains its desirable physical properties. There is only one serious drawback to the use of castor oil in internal explosion engines, namely, its great susceptibility to direct oxidation. Castor oil used in an engine absorbs oxygen at a rapid rate, forming gums and resins in both the explosion chambers and the crankcase, necessitating careful cleaning at frequent intervals. High grade hydrocarbon oils having correct physical properties will lubricate a water-cooled engine just as efficiently as will castor oil, provided there is not undue leakage of fuel mixtures past the pistons into the crankcase and also provided local overheating of the cylinder surfaces does not occur.

W. P. KENNEDY (M. S. A. E.):—Why is sperm oil used in the case of hot journals?

MR. STRATFORD:—Sperm oil is not really an oil, but a wax of animal origin. It also possesses the high adhesive properties of castor oil, and it is doubtless for this reason that sperm oil alone, or sperm oil blended with mineral oil, is used to remedy the overheating of bearings. As I have just said, some experiments have been commenced at the Bureau of Standards that I hope will answer the question of the why and wherefore far better than I can.

F. H. FLOYD (A. S. A. E.):—I have recently been running some tests on castor oil. Castor oil has a flash test of about 549 and a fire test of 618 deg. Now castor oil is an exceedingly high evaporative test oil, and actually a low flash castor oil will evaporate much faster than the higher flash test motor oil. I think perhaps castor oil is a more oily oil, although that is really questionable when it comes to the selection of what in the trade we term the bright oils, that is, oils from which the paraffin wax has been removed, the oil highly filtered, and the viscosity the same as castor oil, which is about 127 sec. The viscosity is the same with a pure hydrocarbon oil having a flash point of about 510 or 515 deg. I do not believe the results of operating aviation engines will be any different, but those oils, of course, are hard to get in large quantities. I believe they are just as fine as castor oil, with this exception, that the hydrocarbons have not the low cold test that castor oil has. Demonstrations have been made in Detroit with bright cylinder stocks of high class, and we have secured just as fine results.

MR. STRATFORD:—That is really what has been attempted in the production of mineral Liberty Aero Oil. The government specifications, among other things, call for an oil of about 85 sec. viscosity at 212 deg. Most oils having this viscosity, made from paraffin or intermediate base crudes, also possess a high boiling point range.

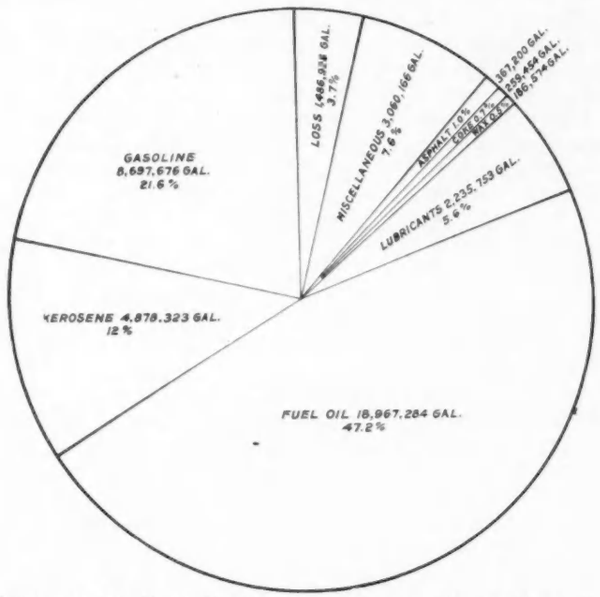
H. W. SLAUSON (M. S. A. E.):—Does carrying on what may be termed the intensified methods of obtaining gasoline reduce the amount of fuel oil available?

MR. STRATFORD:—Very much, indeed. At the refinery the production of fuel oil is inseparably tied up with that of gasoline. The problem is either to crack the gas and fuel oils into gasoline and thus produce a reduced quantity of fuel oil, or to sell all gas and fuel oils as fuel oils and be content with a reduced production of gasoline.

A MEMBER:—Certain manufacturers say that the oil in the crankcase ought to be changed every three or four

or five hundred miles. That oil is generally thrown away and wasted. Should it be treated so?

MR. STRATFORD:—It is a relatively simple matter to recover good lubricating oil from used oil taken from engine crankcases, but it is expensive in these days to recover it in small lots. If all used oil could be collected throughout the country and sent to some central point or points where it could be treated and regenerated, the cost of this operation in quantity would make such processing a highly profitable business and would naturally result in a great saving. The by-products from such recovery would consist chiefly of a burning oil, something like



PRODUCTION OF U. S. REFINERIES IN MARCH, 1913 (U. S. BUREAU OF MINES)

kerosene, and a good residual lubricating oil. If the viscosity of this residual lubricating oil were too heavy it could be blended with light oil and thus be brought back to the original properties of the oil before use.

A MEMBER:—What is so-called casinghead gasoline?

MR. STRATFORD:—Casinghead gasoline is extracted from natural gas. Two general methods are employed in doing this. First, if the gasoline content is high, a compression method is used. The gas, as it issues from the wells, is passed through compressors, where it is compressed, then cooled when gasoline condenses out. After one or more compressions and condensations, the gas is then forced to bubble through an absorbing oil contained in a tall tank for the purpose of removing all traces of gasoline left in the gas. When the absorbing oil becomes saturated it is pumped to a steam still and the gasoline separated by distillation, the oil being returned to the absorber. These absorbers are usually arranged in batteries to permit a continuous operation.

The second method is purely an absorption method. The gas is forced to bubble through a certain depth of oil, which absorbs the gasoline. The method of gas compression is rarely ever used on gases containing less than one gallon of gasoline per thousand cubic feet of gas. Absorption methods may be profitably used on gas containing only one pint of gasoline per thousand cubic feet. The richest natural gas contains about five gallons of casinghead gasoline per thousand cubic feet.

A MEMBER:—Where did it get the name casinghead?

MR. STRATFORD:—Casinghead gasoline comes through the well casing with natural gas, and I suppose a head had to be put on the casing to hold the gas in; hence the name.

A MEMBER:—Is oil ever treated with sulphuric acid so as to spoil it in any way? Is there any difference between one hydrocarbon oil and another in oily properties or in adhesive properties, the viscosity being the same?

MR. STRATFORD:—If the oil film on the bearing surfaces is contaminated the lubricating efficiency might drop off, but with equal chemical purity and viscosity I should say that the lubricating efficiency of two hydrocarbon oils would be equal.

The injury of hydrocarbon oils by overtreatment is very unlikely; considering oils treated under the same general conditions of temperature, etc., increased amounts of sulphuric acid would only tend to remove additional quantities of color bearing and unsaturated compounds. In general, it may be said that the quantity of acid used in treating lubricating distillates is largely governed by the losses of oil in the form of acid sludge. This loss must be kept down as low as possible, at the same time using sufficient acid to clean the oils properly. Squibbs medicinal oil and Nujol are good examples of very heavy treatment with sulphuric acid. These oils are mixtures of chemically pure hydrocarbons and they have not been injured in any way.

International Aircraft Conference

By COKER F. CLARKSON* (*Member of the Society*) *Report at* SEMI-ANNUAL MEETING

THE International Aircraft Standards Conference held in London during February, March and April was the occasion of the first meeting of American, British, French and Italian engineers in which a large number of interrelated subjects were discussed under Governmental auspices, with the advantage of frank and full submission of practice and research data resulting from recent intense development. It was the first occasion of a meeting of the kind during an unprecedented world conflict of arms, a meeting which would have been impossible in the present stage of commercial development, except under the prevailing circumstances. The question of holding the conference had been discussed for several months. The need for it was obvious. After the general plan of procedure was agreed upon and the place of meeting settled, the American delegation, consisting of fourteen men, was organized and proceeded to London. And the result of the conference was very much worth while.

It clearly marked the beginning of a new order of things in international engineering work. A striking effect of the war in this country is the close and valuable cooperation between engineers of different ties and affiliations. The same thing has come to pass in Great Britain, where the event is naturally more conspicuous

*General Manager of the Society.

owing to the fact that there engineers engaged in kindred endeavors have in the past held more aloof from each other than has been the general habit in this country. The works manager of a leading British aeronautic engine factory told us that whereas before the war interchange of visits between works managers of plants like his was practically unknown, this had become common and was of great benefit professionally and also from a production standpoint.

The gracious and hearty manner in which they were received will never be forgotten by the members of the American delegation. After visits under the guidance of the British Air Council to factories engaged in aircraft production of interest in connection with the work of the commission, the committee sessions, of which scores were held, were commenced, a preliminary general meeting having been had, at which the objects of the American delegation were stated to be to offer supplies to England, France and Italy, and to settle on mutually satisfactory standards and specifications in fighting for the same world ideal.

At a session at which representatives of Canada, Italy, Great Britain and the United States were present, spokesmen of the British Ministry of Munitions explained that the British Engineering Standards Association had taken over the important sphere of action of aircraft standardization work, relieving the technical department of the Ministry of Munitions; and emphasized the fact that a body that associates with itself the manufacturers intimately concerned with the production of needed materials, thereby can realize the possibilities of what can actually be done during the war—which is the most important thing. It was pointed out that detail standardization of aircraft materials among the Allied Powers is based on principles so obvious that they really do not require even to be emphasized; and as for the importance of aircraft, it was convincingly stated that those who feel hopeless as to the possibilities of gaining a definite military victory, can have no real knowledge of the power of aircraft.

It was made clear on behalf of France that it is realized that the most effective means of accomplishing a well-regulated division of work is to obtain a systematic standardization of all raw material and of manufactured parts, with the object of reducing the varieties produced to a strict minimum.

The representatives of Italy gave assurance of cordial support of the important work, as having a very important bearing on the Allied aircraft program.

The subjects considered at the Inter-Allied Aircraft Conference included in part: limits and tolerances for metric sizes of ball and roller bearings, fabrics, dopes, electrical parts, streamline and swaged wires, gasolines and oils, glues and cement, instruments, light alloys, magneto dimensions, nomenclature, rubber, screw threads, spark-plugs, steels, seamless tubing, timber, turnbuckles, wheels and tires, wires and cables.

A good practical question is: What was accomplished, at least in general terms?

An immense amount of valuable information was gained and exchanged. Many points of practice were explained and clarified, found harmonious or reconcilable or better left different. Detail systematic work on nomenclature was started. Lists of the important stability terms which have been agreed to in Great Britain by the Department of Aircraft Production, the National Physical Laboratory and the Aeronautical Society of Great Britain have been furnished us for criticism. The relative advantages of the different methods employed in the splicing of timber were outlined. The American and the British practices in the fabrication of ply-woods are in unison. Valuable information on casein cement is available. British and American specifications for glue are in accord, although a uniform method of testing the glue is needed.

Only immaterial modification of the S. A. E. spark-plug is necessary to make it interchangeable with the British.

While the number of steel wire cables in use in Great Britain exceeds the number in use in the United States, the requirements of American airplanes can be met completely by British sizes.

These items are only examples from a long list. It is very clear that it would be folly for the inter-allied countries not to interchange thoroughly and systematically and to the greatest extent possible all information looking toward the unification and simplification of aircraft specifications and the facilitating of delivery of supplies. It can be stated that two beneficial results of the trip of the American delegation were the shipment abroad of materially increased supplies of spruce, and assurance of early delivery of Liberty engines in relatively large number.

A subject we shall have with us for some time is the standardization of the elementary units of mechanical construction—the old metric and inch problem. The possibility of a system of notation of bolts acceptable in countries using either the inch or the metric system was considered by the American commission. In a table which was submitted each bolt diameter was designated by a number indicating the number of eighths of an inch in the diameter; a $\frac{5}{8}$-in. bolt being No. 5, a $1\frac{1}{4}$-in. bolt No. 10, and so on. To designate the pitch two methods were specified in the table; one, the number of threads per inch, and two, five times this number per unit of 127 mm. In countries using the inch system, bolts would be designated, for example, 4 x 13, 6 x 10, 10 x 7; in those using the metric system the designations would be 4 x 65, 6 x 50, 10 x 35.

In Great Britain and America one manner of designation of diameter would under the plan suggested simply be exchanged for another. In countries in which the metric system is employed, designation in terms of a series of numbers related to millimeter diameters by the factor 3.175 would be substituted.

There is nothing particularly novel in this suggested system of notation. At a conference held in Paris in 1914 a proposal substantially like it was made in connection with pipe threads, so far as pitch designation is concerned.

The establishment of international aircraft standards adequate in merit and quantity involves, of course, a relatively large undertaking. Due authority and support by our Government as well as the Allied Governments are essential in addition to competent organization and execution. There must be proper coordination with national standards and diligent work through an international commission. The principal end to seek is plentiful supply of suitable materials and parts for the war purposes.

Vol. III. July, 1918 No. 1

International Aircraft Standards

By CHAS. M. MANLY* (*Member of the Society*) *Report at* SEMI-ANNUAL MEETING

AS full information has already been given regarding the origin and personnel of the recent conferences held in London on aircraft standardization, I have thought it best to confine this paper to a brief outline of the general situation with respect to uniformity of specifications and practices in aircraft work in this country and Great Britain. Some reference will be made to the later conferences held with the representatives of France and Italy, but as no attempt was made to go into matters in detail at these later and international conferences, most of the data here given will refer to the seventy or more preliminary conferences held with the British representatives in which we examined, compared and discussed our respective specifications and practices in full detail.

The thing that we desire, and are attempting to do, is to reach an agreement as to what are suitable materials that can be procured in sufficient quantity for, and worked by known processes into, parts for aircraft; and what are suitable relative dimensions of minor parts that are used in large quantities for fastening together the more important members which must necessarily be subject to special design.

By agreeing on definite standards as to the composition and properties of such materials, and on definite relative proportions of such minor parts, the production capacity of our manufacturers of raw material and minor parts can be employed to the greatest advantage.

The main subjects dealt with and the present status of the standardization work on these subjects, may be briefly stated as follows:

I—Specifications for Steels

Owing to the great difference between the general practice in steel specifications in England and America, it was seen that it would be unwise to attempt to secure the adoption of international specifications at the present time, and that the important thing to do, as affecting the ready supply of such materials as the British might require from American manufacturers, was to assist them in drawing up a set of steel specifications embodying what they thought they required, in order to cause the least disturbance in their production when American materials were substituted for British, and also to expedite their securing of such materials from this country.

A. L. Colby, representing the American Society for Testing Materials, gave a great deal of attention to the study of the differences between the various American and British specifications, while we were on the steamer, and he devoted his time most continuously and effectively in carrying on the conferences with the British representatives. The result of these labors is given in an exceedingly complete report which he made to the Aircraft Board, promptly upon his return in April. Recently we have received from the British Engineering Standards Association the printed proofs of the tentative specifications which are being submitted to the American steel makers for their criticism. Our own steel committee is expected to investigate these specifications most thoroughly and determine whether they can recommend them as the basis for standardization of specifications between this country and Great Britain.

II—Steel Tubing for Structural Purposes

Several conferences were held with the British representatives in order to secure as complete information as possible in regard to the manufacturing processes which were being employed by them in securing their high-grade tubing, which is superior to the product we are getting in this country. We were most fortunate in securing the very hearty cooperation of Lieut.-Com. H. M. Wylie in obtaining this information on manufacturing processes, and we are hoping to secure equally effective cooperation from American manufacturers in improving the quality of steel tubing for aircraft. In connection with improving the quality of the tubing, it is also recommended that we adopt the limited number of sizes and gages of tubing which the British have standardized, not only for the sake of uniformity but more particularly to secure the valuable property the particular gages they have selected possess, of having one tube a telescopic fit *inside* the next larger size, and *outside* the next smaller size. The particular gages which the British have selected for general structural purposes are: 17 B.W.G. (0.056 in.); 20 B.W.G. (0.036 in.), and 22 B.W.G. (0.025 in.) thick, with a tolerance variation of, minus zero, plus 0.004 in., the nominal outside diameters ranging from ¼ to 2⅛ in., advancing by eighths, except for the addition of the 5/16 in. and 7/16 in. sizes. They have also adopted, as extra tubes for sockets, a series of sizes with a gage thickness of 22 B.W.G. (0.025 in.) and the same tolerance variation, the intermediate sixteenths sizes beginning with 9/16 and progressing to 2 1/16 in. diameter, advancing by ⅛ in., these socket tubes of this gage forming a telescopic fit with the regular 22-gage structural tubes, 1/16 in. smaller. In the 17-gage series, the sockets are made from the next larger size, advancing by ⅛ in., except in the case of the 5/16-in. and 7/16-in. sizes. The tolerance variation on outside diameter of the structural tubes is, plus or minus, 0.004 in. With the thickness and diameter tolerances above specified, the average clearance between the tube and socket is about 0.008 in., thus providing suitable space for brazing or sweating processes.

The British also have three special standard thicknesses of heavier gage, the first having a thickness of 0.090 in., minus zero, plus 0.007 in., and this fits over a tube 3/16 in. smaller; the second a thickness of 0.120 in., minus zero, plus 0.009 in., and this fits over a tube ¼ in. smaller, while the third has a thickness of 0.150 in., minus zero, plus 0.011 in., and this fits over a tube 5/16 in smaller. It is readily seen that this series of sizes and thicknesses is unusually attractive from a stock-keeping point of view, from the fact that it enables practically all the short pieces to be used up for sockets, thus reducing the waste to a minimum. It should be equally attractive from a manufacturing point of view, in that it limits the number of sizes and thicknesses to be manufactured to the minimum amount that will permit the designers to have a proper range to meet their requirements.

As stated previously, the physical requirements of the

*Chief Inspection Engineer, Curtiss Aeroplane and Motor Corporation.

British tubing specifications are so much higher than our own production processes give, that it will be useless to attempt to coordinate our physical requirements with theirs until we are able to improve the quality of the material by improving our processes. It is most important that this be done and every effort should be made to secure such a result at the earliest time possible.

III—Glue and Cement

It was found that while we were, without doubt, fully abreast of the best British practice in the making of glue, we were undoubtedly far behind them in the matter of casein cements. We, therefore, secured from them full specifications and samples of the new casein cement, devised by the Aircraft Inspection Department, and expect the American manufacturers to be able to produce equally good, or better, cement of this type. I am personally of the opinion that a thorough investigation should be made as to the relative ability of glues and casein cements to withstand vibration, although I was assured by the British representatives that the casein cement had proved thoroughly satisfactory under the most severe conditions of vibration. The casein cement is attractive, owing to its good qualities of resisting moisture and being used cold, thus eliminating the necessity for the very careful watching which has to be maintained with hot glue to insure its being used at the proper temperature, or not being chilled before the parts are actually clamped together. On account of the large volume of milk procurable in this country, we should be able to readily supply the casein, and we should certainly be able to devise methods of manufacturing it of the proper quality.

It was generally agreed that our present information on glue was not sufficient to enable us to say definitely what constituents control the strength and sticking property of glue, and that research along these lines should be carried out as promptly as possible.

There was also considerable opinion that the standard methods of making physical tests of glue do not give us a real indication of the tensile strength of the glue, since the shearing strength may be quite out of proportion to the tensile strength.

It was also generally agreed that while none of the forms of test-specimen is entirely satisfactory, yet the British form of specimen in which two thin strips of wood are overlapped at the adjacent ends and glued at the overlapping portions, this test piece being then pulled in a tension machine, gives a result more likely to be free from any wedging action, than any form where one member is forced past one or more other members in a compression machine.

Boxwood is preferred for glue tests, but American walnut is really used by the British and recommended owing to the limited supply of boxwood available.

While liquid glues which can be used cold are being requisitioned for repairs at the front, still it is hoped that casein cement will displace such glues.

IV—Timber

(*a*) *Seasoning.*—It was found that the British had made excellent progress in the art of artificially drying timber and that several modifications about which we learned from them might well be introduced in our own processes.

(*b*) *Conservation.*—We endeavored to impress on them the great importance of conserving the spruce supply to the utmost, and with this end in view urged them to secure the release by their technical department of every available form of splicing and laminating beams and other large parts. They responded most vigorously through their spar splicing and built-up spare committees. These quickly released some designs for spliced and laminated spars which added largely to the amount of material available for these parts. Their experience with Douglas fir and Louisiana cypress as substitutes for spruce has not been very encouraging.

(*c*) *Propeller Woods.*—We found that the British had gone further than we had in permitting the use of side and end joints in the laminæ of propellers, owing to their shortage of available material. We must urge our own designers and constructors of propellers to practice the utmost economy of material in conserving our supplies of walnut and mahogany.

(*d*) *Ply-wood.*—The British are making extensive use of ply-wood and are anxious to secure a large supply of cut veneers for this purpose. They especially desire veneers of yellow birch, ash and satin walnut or American red gum.

Casein cement is used almost exclusively by them in making their ply-wood and is proving most satisfactory. Samples of ply-wood were exhibited which had been three months in water without any appearance of having suffered. Another sample had been soaked in boiling water without separating the plies, but strength tests after this treatment had not been made.

V—Dopes

Much valuable information was obtained from the British with reference to dopes. Their researches on solvents, pigments and protective varnishes were found to be well advanced, and it is hoped that we will be able to extend the available information on these most important subjects by building on the excellent ground-work they have laid.

We urged the extreme importance of immediate steps being taken by them, as well as by ourselves, in conserving the available supply of solvents, by the installation of solvent recovery plants and processes in all dope rooms of any considerable size. We investigated one solvent recovery process in France and now have plans under way for the installation, in this country, of test plants for solvent recovery according to two different American processes.

The Italians especially have been very short in their supplies of acetate dopes, and every effort must be made to assist them in obtaining a more adequate supply.

VI—Fabric

The British were strongly of the opinion that their linen fabric, in the making of which they have become most proficient, was not safely replaceable by any other material. Our specifications for cotton fabric and samples thereof were presented to them, and as a result of the tests to which they subjected these samples of the fabric, they agreed as to its suitability for replacing linen, of which the supply is becoming short, and I understand ordered a large quantity of our cotton fabric for their own use.

The weave of the fabric is found to be of great importance in enabling the dope to tighten it, as well as in insuring that the dope will not readily loosen its hold on the fabric.

VII—Gasoline-Resisting Tubing and Shock Absorber Cord

(*a*) *Gasoline-Resisting Tubing.*—It was found that our S. A. E. Specification for gasoline-resisting tubing, which had been practically copied from the British specification which we had at the time it was drawn up, differed in two respects, the first being that we require a rubber content of only 25 per cent while the British require 35

per cent, and the British representatives stated that their experience had shown that with only 25 per cent the tubing is extremely short lived; and the second, that the British require tubing for water, oil, etc., be of the same specification as the gasoline-resisting tubing in order to eliminate the danger of tubing of a different specification being erroneously used for gasoline. They pointed out that the cost of the rubber was far from being important, since rubber was costing at the time only 20 pence, or 40 cents, per pound while the cotton fabric was costing 68 pence, or $1.36, per pound.

The British were also of the opinion that our aging test was unsatisfactory. They had had somewhat similar tests and had abandoned them but are attempting to devise one that will be satisfactory.

(*b*) *Shock-absorber cord.*—As we had no specification for shock-absorber cord we were unable to make comparisons, but we gained much of value in meeting with their panel committee, which was redrafting their specification. We shall recommend the adoption of the specification they completed at these meetings.

VIII—Propeller Hub and Fixing

We found that this subject was one of extreme interest to the British as well as to ourselves, especially in connection with eight-cylinder engines.

We later found at the international meetings that it was also of equal importance to the French and the Italians. Not only had trouble been experienced in the case of eight-cylinder engines without flywheels, in the blistering of the shaft and hub where they join, but even where the hubs were pressed rigidly on the shafts there was trouble from heating between the wooden boss of the propeller and the flange plates of the hub. It had been found necessary to increase the size of flange plates for such engines and in some tests, disks of brake lining had been put in between the hub flanges and the propeller boss. This had, however, in some cases caused the propeller to split at the tips of the blade owing to the excessive rigidity of the drive.

It was agreed that it would be unwise to attempt to standardize the method of fastening the hubs to the shafts, but that our suggestion that the fit of the taper on the usual tapered type of fitting be relieved, except for about one-quarter the length of the taper at the large end, be tried out. It was agreed, however, to try to agree on the important matters that affect interchangeability of propellers between engines, namely, the diameter of the bolt circle in the flanges, the number and size of the bolts, and the thickness of the wood boss of the propellers.

IX—Wheels and Tires

We were in agreement on the Palmer type of rim and tire on the four sizes we had adopted, since we had taken the British standards for these. Additional larger sizes are under consideration for standardization.

The sizes of axle which they have adopted are: 1.500, 1.750, 2.00, 2.165 and 2.375 inches. If larger sizes are required, we will make mutual inquiries and keep together if possible. The bushings for these were agreed on, as our four sizes are already in accord with their first four sizes.

X—Standard Fittings (Rigging and Components)

It was agreed that the following parts might usefully be standardized internationally, or, at any rate, that we might have a British-American standard for them; bolts, nuts, washers, eyebolts, cables, wires, streamline wires, swaged rods, eyelets, turnbuckles, shackles, universal-joints, fork-ends, clevis pins, pulleys, fairleads, wiring lugs or clips, and taper sockets for steel wire ropes. It was not proposed to standardize the design of these, except on such dimensions as are necessary to insure that fittings of the same size and strength would be interchangeable internationally.

XI—Electrical Parts

The main matters dealt with under this heading were: Standard electric pressure for use on aircraft; gun and clothing heaters, cables, wireless valves, standard pressures and tests for valves, plug connections, secondary batteries, engine-heating, lamp sockets, fuses, and lamps attached to reflectors.

The British have standardized on twelve volts across the outer wires of a three-wire system, with six volts between the middle and either outer wire. Current for the instrument lights is taken from one cell, a change-over switch being provided so that a cell on either side of the middle wire can be used. It is important that we reach an agreement, at least with the British, as to uniformity of voltage and plug connections; both these affect the interchangeability of heated clothing, gun-heaters and batteries.

XII—Instruments

These being so largely a matter of design, it was felt to be unwise to attempt very much in the way of international standardization of instruments. The drawings and specifications of the recently adopted S. A. E. tachometer drive-shaft were presented, and while they were not entirely satisfied that it was exactly suited for general international standardization, still they received it favorably as an advance in drive-shaft construction.

XIII—Magnetos

We were found to be in accord on magnetos, except that the British have found it necessary to increase the maximum overall width allowance from 127 to 160 mm., and the maximum overall length allowance from 254 to 260 mm., to take care of a more rigid fastening of the distributer. We must consider the matter carefully and adopt these changes as soon as possible if they seem wise, as they are based on experience. As we have not yet standardized starting magnetos, we should look carefully over the British standards for these, with a view to the adoption of their limiting dimensions.

XIV—Spark-Plugs

Full agreement was reached on all matters affecting interchangeability, and a really Anglo-American standard embodying the best of both previous separate standards was agreed on for recommendation.

XV—Water and Fuel Systems

It was agreed to standardize on the outside diameter of metal tubing for such systems, so as to agree with the concurrently adopted standard of specifying the rubber tubing size by inside diameter.

Much attention was given to examining the designs and constructions of unions, elbows and similar fittings recently submitted as suitable for standardization by British manufacturers, and it is hoped that we will be able to benefit by what we learned, as well as to try to bend our general practices in the design and construction of these parts as near together as may be necessary for general interchangeability.

XVI—Installation of Apparatus

An interesting meeting on this subject was held with the British representatives, and while there is little for standardization in it, yet there is a great deal to be learned by a frequent interchange of views.

XVII—Light Alloys

Much valuable information on this subject was gained, and we hope to use it in connection with researches which are in progress in this country.

STANDARDIZATION AT THE SEMI-ANNUAL MEETING

REPORTS of the Divisions were considered at a meeting of the Standards Committee, held June 16, at the Engineers' Club, Dayton, Ohio, and were presented to the Society at the Business Session held on June 17. These Division reports are given on the following pages in their final form as accepted at that meeting.

Before becoming S. A. E. Standards or Recommended Practices, however, these reports must receive the affirmative letter vote of the majority of the voting members of the Society.

A summary of the subjects covered by the various Division reports was printed in the June issue of THE JOURNAL.

REPORT OF AERONAUTIC DIVISION

(As accepted for submission to mail vote.)

THE following report is submitted by the Aeronautic Division:

1. *Turnbuckles.*—The dimensions for turnbuckle and associate fittings, in the formulation of which representatives from aircraft manufacturers and turnbuckle manufacturers participated, were approved by the Society June, 1917, in Washington. They were never sent out in data sheet form (for the S. A. E. Handbook) because it was desired to have the American and British types interchangeable, thus materially facilitating repairs at the front.

Standard turnbuckle dimensions have since been received, and compared with those proposed here. By widening the slot in the fork end of the S. A. E. 1600-lb. and 3200-lb. sizes from 0.109 to 0.150 in., thus permitting the use of the lower-grade steels, which are more easily obtained for strainer clips, and by making two or three other minor modifications, the S. A. E. and British turnbuckles can be made practically interchangeable. The accompanying tabulations show the turnbuckle dimensions as recommended by the Division and approved by the various representatives previously mentioned.

In order to prevent off-centering of the slot it is recommended that the tine thickness be governed by the formula $W\ (min.) \doteq \frac{F\ (min.) - G\ (max.)}{2}$

The complete turnbuckle table is shown for analysis, but only the important dimensions influencing interchangeability will be published in the S. A. E. Handbook.

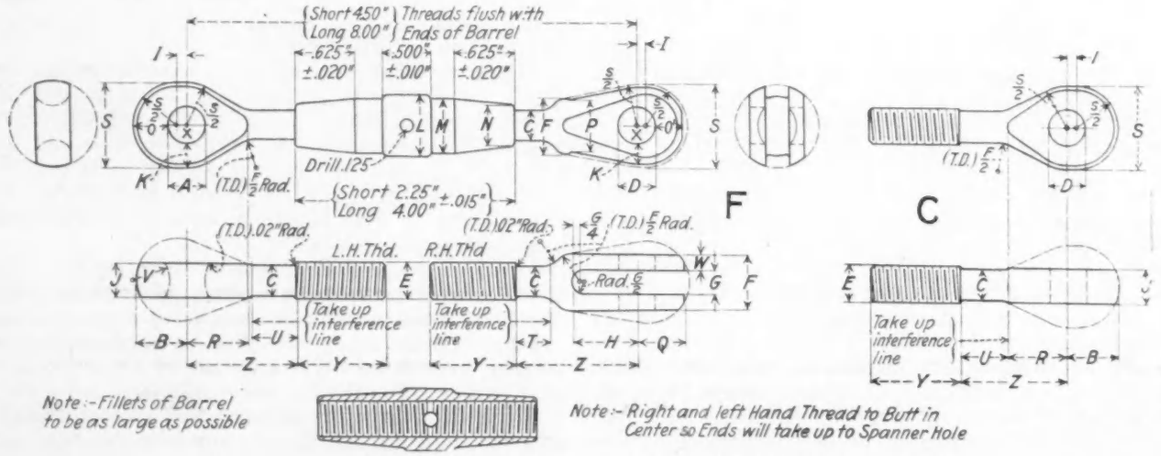
In presenting this recommended practice for turnbuckle dimensions it is not intended to limit design but rather to aid manufacturers in designing, and thus eliminate all differences that would otherwise interfere with interchangeability. The dimensions of the slots and pin diameter in the fork end, and size of hole in the eye end, are the most important factors influencing interchangeability.

The fit of the threads in the barrel, the protective coating, and method of inspection, are to be specified by the purchaser. As a matter of information, the present practise for threads requires that they must have a snug, true fit, allowing barrel or shank to be turned by hand, and showing no perceptible slackness in fit or end shake with three threads exposed.

2. *Loops for Non-flexible Single-strand Steel Cable.*—The serving wire for these loops* now recommended is 0.0204-in. soft-steel tinned wire. It has been found that 0.0180-in. wire permits the use of a thimble having the same nominal size as the cable, whereas with the 0.0204-in. wire a thimble one size larger is necessary.

Some manufacturers state that serving is not neces-

*See S. A. E. Transactions, Vol. 12, Part II, p. 2, and S. A. E. Handbook, Vol. I, sh. 45d.


Short 4.50" Long 8.00"
Threads flush with Ends of Barrel
.625" ±.020"
.500" ±.010"
.625" ±.020"
Drill .125"
Short 2.25" ±.015" Long 4.00"
(T.D.) .02" Rad.
L.H. Thd.
R.H. Thd.
Take up interference line
F
C
Note:-Fillets of Barrel to be as large as possible
Note:-Right and left Hand Thread to Butt in Center so Ends will take up to Spanner Hole

DIMENSIONS OF PROPOSED S. A. E. TURNBUCKLES. (SEE TABLE ON OPPOSITE PAGE)

DIMENSIONS OF PROPOSED S.A.E. TURNBUCKLE

S. A. E. Symbols (See Key)	GENERAL: Strength,* Turnbuckle and 19-Strand Wire, Lb.	GENERAL: Area of Steel Req'd, Sq. In. — Ultimate Strength 105,000 Lb. per Sq. In.	GENERAL: Area of Steel Req'd, Sq. In. — Ultimate Strength 125,000 Lb. per Sq. In.	GENERAL: Cable Diam., In.	GENERAL: Take-up from Threads Flush With End of Barrel to Spanner Holes, In.	EYE AND CLEVIS (C) END, Ultimate Strength, 125,000 Lb. per Sq. In.: Will Take 0.018 In. Serving. Use Same Size Thimble as Cable Size	Equals $\frac{S}{2}+1$	Allows Approx. 0.015 In. Below Root Dia. of Thread	Thimble Radius				Area Total Section, Sq. In.		Equals $\frac{S+C}{2}$ Approx.	Five Sizes, Same as Fork End	Take-up Based on Root Diam. U		Area of Hole A	Equals 2E+0.125	
						A	B	C	V	E	I	J	2K	O	R	S	Take-Up	Root Dia.	X	Y	Z
Tolerances	.....	.....	.....	.....	....	+.010 −.000	+.005 −.005	+.006 −.000		+.000 −.004		+.005 −.005				+.007 −.007				+.040 −.000	+.030 −.010
16 S F	1600	.0152	.0128	.109 ($\frac{7}{64}$)	1.04	.219 ($\frac{7}{32}$)	.28	.133	.175	.190 (#10)	.03	.188 ($\frac{3}{16}$)	.0466	.0292	.326	.500 ($\frac{1}{2}$)	0.80	.1467	.0376	.505	1.125 ($1\frac{1}{8}$)
16 L F	1600	.0152	.0128	.109 ($\frac{7}{64}$)	2.79	.219 ($\frac{7}{32}$)	.28	.133	.175	.190 (#10)	.03	.188 ($\frac{3}{16}$)	.0466	.0292	.326	.500 ($\frac{1}{2}$)	1.67	.1467	.0376	.505	2.000
21 S F	2100	.0200	.0168	.125 ($\frac{1}{8}$)	1.00	.219 ($\frac{7}{32}$)	.28	.155	.175	.216 (#12)	.03	.188 ($\frac{3}{16}$)	.0470	.0285	.328	.500 ($\frac{1}{2}$)	0.59	.1696	.0376	.557	1.125 ($1\frac{1}{8}$)
21 L F	2100	.0200	.0168	.125 ($\frac{1}{8}$)	2.74	.219 ($\frac{7}{32}$)	.28	.155	.175	.216 (#12)	.03	.188 ($\frac{3}{16}$)	.0470	.0285	.328	.500 ($\frac{1}{2}$)	1.47	.1696	.0376	.557	2.000
32 S F	3200	.0304	.0256	.156 ($\frac{5}{32}$)	0.62	.281 ($\frac{9}{32}$)	.353	.189	.200	†.250 ($\frac{1}{4}$)	.04	.219 ($\frac{7}{32}$)	.0676	.0422	.402	.625 ($\frac{5}{8}$)	0.69	.2037	.0621	.625 ($\frac{5}{8}$)	1.125 ($1\frac{1}{8}$)
32 L F	3200	.0304	.0256	.156 ($\frac{5}{32}$)	2.36	.281 ($\frac{9}{32}$)	.353	.189	.200	†.250 ($\frac{1}{4}$)	.04	.219 ($\frac{7}{32}$)	.0676	.0422	.402	.625 ($\frac{5}{8}$)	1.56	.2037	.0621	.625 ($\frac{5}{8}$)	2.000
46 S F	4600	.0438	.0368	.188 ($\frac{3}{16}$)	0.62	.313 ($\frac{5}{16}$)	.384	.243	.250	†.3125 ($\frac{5}{16}$)	.04	.281 ($\frac{9}{32}$)	.0926	.0574	.465	.688 ($\frac{11}{16}$)	0.68	.2584	.0767	.750 ($\frac{3}{4}$)	1.125 ($1\frac{1}{8}$)
46 L F	4600	.0438	.0368	.188 ($\frac{3}{16}$)	2.37	.313 ($\frac{5}{16}$)	.384	.243	.250	†.3125 ($\frac{5}{16}$)	.04	.281 ($\frac{9}{32}$)	.0926	.0574	.465	.688 ($\frac{11}{16}$)	1.56	.2584	.0767	.750 ($\frac{3}{4}$)	2.000
61 LF	6100	.0584	.0488	.219 ($\frac{7}{32}$)	2.08	.344 ($\frac{11}{32}$)	.435	.256	.300	†.375 ($\frac{3}{8}$)	.06	.281 ($\frac{9}{32}$)	.1004	.0611	.503	.750 ($\frac{3}{4}$)	1.55	.3209	.0928	.875 ($\frac{7}{8}$)	2.000
80 LF	8000	.0760	.0640	.250 ($\frac{1}{4}$)	2.00	.375 ($\frac{3}{8}$)	.498	.306	.350	†.375 ($\frac{3}{8}$)	.06	.328 ($\frac{21}{64}$)	.1500	.0933	.619	.875 ($\frac{7}{8}$)	1.37	.3209	.1105	.875 ($\frac{7}{8}$)	2.000

*Breaking strength of spliced cable is about 10 per cent less than undisturbed wire and yielding point of solid wire loops is about 20 per cent less than spliced wire strength.
All Dimensions in Inches.
KEY TO SYMBOLS—The numbers indicate the turnbuckle strength in hundred pounds. The following letter, "Short" or "Long." The last letter indicates whether Fork (*F*) or Clevis (*C*) End is used in combination with Eye End. When the turnbuckle make-up calls for ends to be alike, one end shall have right hand, and the other end left hand thread.
††+0.000−0.006 in.

S. A. E. Symbols (See Key)	BARREL: Naval Brass No. 11030 Ultimate Strength 67,000 Lb. per Sq. In. or Equivalent: L	M	N	Thds. U. S. Form: Diam.	Pitch	FORK (*F*) END, Ultimate Strength, 125,000 Lb. per Sq. In.: Allows Approx. 0.015 In. Below Root Dia. of Thread: C Diam.	Area, Sq. In.	Strength: 105,000 Lb. per Sq. In.	Strength: 125,000 Lb. per Sq. In.	D	E	F	4 Clip Thicknesses 1-10, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{1}{2}$ In. G	H	I	Area Total Section, Sq. Inches: 4K	O′	P	Q	S	Take-up based on Root Diam. T: Take-up	Root Diam.	Area of Hole D: X	Equals 2E+0.125 In.: Y	Two Lengths, Short and Long Barrels: Z
Tolerances	+.005 −.005	+.005 −.005	+.005 −.005	. .	. .	. .	. .	. .	. .	+.010 −.000	+.000 −.004	+.010 −.005	+.010 −.000	+.010 −.005		. .	. .	. .	. .	+.007 −.007	. .	. .	. .	+.040 −.000	+ 030 −.010
16 S F	.375 ($\frac{3}{8}$)	.281 ($\frac{9}{32}$)	.250 ($\frac{1}{4}$)	#10	32	.133	.0139	1450	1738	.188 ($\frac{3}{16}$)	.190	.313 ($\frac{5}{16}$)	.150	.469 ($\frac{15}{32}$)	.03	.0405	.0240	.0410	.250 ($\frac{1}{4}$)	.500 ($\frac{1}{2}$)	0.520	.1467	.0276	.505	1.125 ($1\frac{1}{8}$)
16 L F	.375 ($\frac{3}{8}$)	.281 ($\frac{9}{32}$)	.250 ($\frac{1}{4}$)	#10	32	.133	.0139	1450	1738	.188 ($\frac{3}{16}$)	.190	.313 ($\frac{5}{16}$)	.150	.469 ($\frac{15}{32}$)	.03	.0405	.0240	.0410	.250 ($\frac{1}{4}$)	.500 ($\frac{1}{2}$)	1.395	.1467	.0276	.505	2.000
21 S F	.375 ($\frac{3}{8}$)	.328 ($\frac{21}{64}$)	.281 ($\frac{9}{32}$)	#12	28	.155	.0189	1985	2360	.188 ($\frac{3}{16}$)	.216	.313 ($\frac{5}{16}$)	.150	.500 ($\frac{1}{2}$)	.03	.0405	.0240	.0410	.250 ($\frac{1}{4}$)	.500 ($\frac{1}{2}$)	0.500	.1696	.0276	.557	1.125 ($1\frac{1}{8}$)
21 L F	.375 ($\frac{3}{8}$)	.328 ($\frac{21}{64}$)	.281 ($\frac{9}{32}$)	#12	28	.155	.0189	1985	2360	.188 ($\frac{3}{16}$)	.216	.313 ($\frac{5}{16}$)	.150	.500 ($\frac{1}{2}$)	.03	.0405	.0240	.0410	.250 ($\frac{1}{4}$)	.500 ($\frac{1}{2}$)	1.375	.1696	.0276	.557	2.000
32 S F	.438 ($\frac{7}{16}$)	.391 ($\frac{25}{64}$)	.328 ($\frac{21}{64}$)	$\frac{1}{4}$	28	.189	.0280	2940	3500	.250 ($\frac{1}{4}$)	†.250	.438 ($\frac{7}{16}$)	*.203 ($\frac{13}{64}$)	.625 ($\frac{5}{8}$)	.04	.0660	.0380	.0770	.279 ($\frac{9}{32}$)	.625 ($\frac{5}{8}$)	0.306	.2037	.0491	.725	1.125 ($1\frac{1}{8}$)
32 L F	.438 ($\frac{7}{16}$)	.391 ($\frac{25}{64}$)	.328 ($\frac{21}{64}$)	$\frac{1}{4}$	28	.189	.0280	2940	3500	.250 ($\frac{1}{4}$)	†.250	.438 ($\frac{7}{16}$)	*.203 ($\frac{13}{64}$)	.625 ($\frac{5}{8}$)	.04	.0660	.0380	.0770	.279 ($\frac{9}{32}$)	.625 ($\frac{5}{8}$)	1.181	.2037	.0491	.725	2.000
46 S F	.500 ($\frac{1}{2}$)	.438 ($\frac{7}{16}$)	.406 ($\frac{13}{32}$)	$\frac{5}{16}$	24	.243	.0464	4870	5790	.250 ($\frac{1}{4}$)	†.3125	.438 ($\frac{7}{16}$)	*.203 ($\frac{13}{64}$)	.625 ($\frac{5}{8}$)	.04	.0840	.0480	.0834	.344 ($\frac{11}{32}$)	.688 ($\frac{11}{16}$)	0.320	.2584	.0491	.750 ($\frac{3}{4}$)	1.125 ($1\frac{1}{8}$)
46 L F	.500 ($\frac{1}{2}$)	.438 ($\frac{7}{16}$)	.406 ($\frac{13}{32}$)	$\frac{5}{16}$	24	.243	.0464	4870	5790	.250 ($\frac{1}{4}$)	†.3125	.438 ($\frac{7}{16}$)	*.203 ($\frac{13}{64}$)	.625 ($\frac{5}{8}$)	.04	.0840	.0480	.0834	.344 ($\frac{11}{32}$)	.688 ($\frac{11}{16}$)	1.195	.2584	.0491	.750 ($\frac{3}{4}$)	2.000
61 L F	.625 ($\frac{5}{8}$)	.594 ($\frac{19}{32}$)	.469 ($\frac{15}{32}$)	$\frac{3}{8}$	24	.256	.0515	5400	6430	.375 ($\frac{3}{8}$)	†.375	.563 ($\frac{9}{16}$)	*.203 ($\frac{13}{64}$)	.750 ($\frac{3}{4}$)	.06	.0924	.0620	.1520	.375 ($\frac{3}{8}$)	.750 ($\frac{3}{4}$)	1.040	.3209	.1105	.875 ($\frac{7}{8}$)	2.000
80 L F	.625 ($\frac{5}{8}$)	.594 ($\frac{19}{32}$)	.469 ($\frac{15}{32}$)	$\frac{3}{8}$	24	.306	.0735	7720	9170	.375 ($\frac{3}{8}$)	†.375	.563 ($\frac{9}{16}$)	*.266 ($\frac{17}{64}$)	.781 ($\frac{25}{32}$)	.06	.1152	.0726	.1290	.453 ($\frac{29}{64}$)	.875 ($\frac{7}{8}$)	1.000	.3209	.1105	.875 ($\frac{7}{8}$)	2.000

All dimensions in inches. *Tolerance + 0.015 in. − 0.0000 in. ††+0.000−0.006 in.

sary, as the break never occurs at the loop even when it is not served.

In view of these conditions it is recommended that where serving is specified 0.0180-in. soft-steel tinned wire be used.

3. *Aircraft Bolt-head and Nut Dimensions.*—It is believed that the basic formulas for determining bolt-head and nut dimensions should be recorded so that the system of progression of present standards will be more clearly understood, and, in event of extension, a basis of calculation will be available.

Thorough tests have been made of many bolt-heads and nuts of various thicknesses and grades of steel. As a result it is recommended that the practise for determining bolt-head and nut dimensions be as follows:

Full-strength nuts shall have a thickness equal to three-quarters of the bolt diameter.

Full-strength bolt-heads shall have a thickness equal to one-half the bolt diameter, plus 1/32 in. for ¼ in. and larger sizes; ⅛ in. for Nos. 8, 10 and 12 sizes; and 3/32 in. for Nos. 4 and 6 sizes. Limits on all thicknesses, ±0.005 in.

Thin nuts for shear bolts shall have a thickness equal to one-half the bolt diameter for ¼ in. and larger sizes.

Check nuts shall have a thickness equal to one-half the bolt diameter for ¼ in. and larger sizes.

In view of this it is recommended that the practice stated above shall govern bolt and nut design, but that dimensions for all thin aircraft nuts in sizes smaller than ¼ in. shall be in accordance with S. A. E. full-strength plain-nut practice, as follows:

PLAIN HEXAGON NUTS
(For Bodies and Wings, Not Engines)

Bolt, Size, In.	Threads per Inch	Hex. Short Dia.	Nut Thickness
0.1120 (No. 4)	48	0.250 (¼)	0.094 (3/32)
0.1380 (No. 6)	40	0.313 (5/16)	0.109 (7/64)
0.1640 (No. 8)	32	0.375 (⅜)	0.125 (⅛)
0.1900 (No. 10)	32	0.375 (⅜)	0.141 (9/64)
0.2160 (No. 12)	28	0.438 (7/16)	0.156 (5/32)
0.2500 (¼)	28	0.438 (7/16)	0.188 (3/16)
0.3125 (5/16)	24	0.500 (½)	0.234 (15/64)
0.3750 (⅜)	24	0.563 (9/16)	0.281 (9/32)
0.4375 (7/16)	20	0.688 (11/16)	0.328 (21/64)
0.5000 (½)	20	0.750 (¾)	0.375 (⅜)
0.5625 (9/16)	18	0.875 (⅞)	0.422 (27/64)
0.6250 (⅝)	18	0.938 (15/16)	0.469 (15/32)

All threads U. S. form. Dimensions in inches.

4. *Aircraft Screws and Bolts—Diameter Limits.*—Aircraft bolts are usually long, and pass through wood, so that the fine tolerances specified for automobile screws, which pass through metal, are not required. The full strength of the aircraft bolt must be maintained, and therefore the maximum limit should be the nominal diameter with a normal manufacturing tolerance. In view of this condition it is recommended that the nominal maximum diameter be maintained, with tolerances as follows:

Sizes No. 4 to 10 inclusive, plus 0.000, minus 0.003 in.

In sizes No. 12 to ½ in. inclusive, plus 0.000, minus 0.004 in.

In sizes 9/16 to ⅝ in. inclusive, plus 0.000, minus 0.005 in.

5. *Aircraft Bolts, Thread Pitches.*—The Division has previously recommended* pitches for bolt sizes No. 8 to ⅝ inclusive. Exception has been taken to the 12-32 size, it being asserted that this should be 12-28, to correspond to the A. S. M. E. pitch. At the time the recommendation was made the majority of aircraft manufacturers were using the 12-32 pitch, and in order not to interfere with production it was decided that it should be used as a war measure.

The situation has now changed, and in order to unify American aircraft practice it is recommended that the 12-32 pitch be changed to 12-28 for all S. A. E. aircraft screws and bolts, this change to be made as soon as possible without interfering with production, and to be effective Jan. 1, 1919.

It is also recommended that aircraft bolt sizes 4-48 and 6-40 be added to the list of S. A. E. aircraft screws and bolts.

6. *Washer Face for Screws and Bolts (Progress Report).*—At a subcommittee meeting held in New York on April 10, 1918, it was suggested that the under side of airplane boltheads and the face of nuts should be cut back from 0.010 to 0.015 in., to produce a washer face of diameter equal to the short diameter of the hexagon.

In reconsidering this matter the members of the Division expressed the opinion that the bevel face is fully as good as the washer face, and in view of the fact that the Navy is still ordering according to the S. A. E. specification (namely the bevel face), and that this provides a distinctive mark for aircraft bolts and nuts, the S. A. E. specification should not be changed at present.

It is, however, suggested that further information be obtained as to the comparative quality of workmanship on nut and bolthead faces of both styles. If investigation proves the desirability of changing to the washer face, action can be taken at some future date.

7. *Airplane Engine Testing Specification (Progress Report).*—The airplane engine testing specification presented by the Aeronautic Division at the Standards Committee meeting in January, 1918, was approved by the mail vote of the Society, but was not published because of the many negative votes received. A brief review of the letters received indicated the desirability of referring the matter back to the sub-committee with instructions to review the foreign engine testing specifications, together with the specifications used at present for the testing of American engines; to consider also the general advance of the art, especially in view of the higher compressions now coming into use; and to recommend to the Division such changes as seem advisable.

*See S. A. E. Transactions, Vol. 12, Part II., pp. 10 and 11, and S. A. E. Handbook, Vol. I, sh. 45 k and 45 l.

REPORT OF BALL AND ROLLER BEARINGS DIVISION

(As accepted for submission to mail vote.)

AS an outcome of the conference of the Ball and Roller Bearing Section of the American Aircraft Commission with the British Engineering Standards Committee, held in London, in March, a cablegram was sent to the Society and referred to the Division requesting a modification and revision of tolerances for metric sizes of annular ball bearings.

1. *Annular Ball Bearings.*—After considering the situation, the tolerances on S. A. E. annular (radial) ball bearings have been completely revised, the standard S. A. E. tolerances as to bore and outside diameter being materially reduced in line with the improvement of the art and in close agreement with the suggestions of the above-mentioned conference.

American experience has indicated that the present S. A. E. minus tolerance as to width is unnecessarily small, smaller than in actual American practice, and even smaller than in English practice. This tolerance, therefore, has been changed, being increased from 0.002 to 0.005 inches.

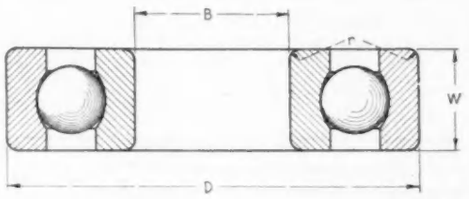
The eccentricity limit of the inner race of the smaller sizes of bearings has been reduced from 0.0008 to 0.0006 inches.

In connection with these changes the tables of annular ball bearings* have been revised to correspond in form with the tables of thrust bearings† already standardized. The complete revisions are shown in the accompanying tables.

2. *Standard Temperatures for Measurements.*—When working to the fine tolerances specified for annular ball bearings a slight change in temperature is sufficient to cause a change in the bearing dimensions, such that the actual measurements are outside the allowable limits.

*See S. A. E. Transactions, Vol. 7, Part I, pp. 108 to 113; Vol. 9, Part I, pp. 38 to 40 and p. 53, and S. A. E. Handbook, Vol. I, sh. 29 to 29c.

†See S. A. E. Transactions, Vol. 12, Part II, pp. 24 to 29, and S. A. E. Handbook, Vol. I, sh. 29f to 29j.



ANNULAR (RADIAL) BALL BEARINGS
S. A. E. Standard Sizes
LIGHT SERIES

Bearing Number	B		D		W Of Individual Rings		Y Corner Radius	
	Mm.	Inches	Mm.	Inches	Mm.	Inches	Mm.	Inches
200	10	0.39370	30	1.18110	9	0.35433	1	0.04
201	12	0.47244	32	1.25984	10	0.39370	1	0.04
202	15	0.59055	35	1.37795	11	0.43307	1	0.04
203	17	0.66929	40	1.57481	12	0.47244	1	0.04
204	20	0.78740	47	1.85040	14	0.55118	1	0.04
205	25	0.98425	52	2.04725	15	0.59055	1	0.04
206	30	1.18110	62	2.44095	16	0.62992	1	0.04
207	35	1.37795	72	2.83465	17	0.66929	1	0.04
208	40	1.57481	80	3.14962	18	0.70866	2	0.08
209	45	1.77166	85	3.34647	19	0.74803	2	0.08
210	50	1.96851	90	3.54332	20	0.78740	2	0.08
211	55	2.16536	100	3.93702	21	0.82677	2	0.08
212	60	2.36221	110	4.33072	22	0.86614	2	0.08
213	65	2.55906	120	4.72443	23	0.90551	2	0.08
214	70	2.75591	125	4.92128	24	0.94488	2	0.08
215	75	2.95277	130	5.11813	25	0.98425	2	0.08
216	80	3.14962	140	5.51183	26	1.02362	3	0.12
217	85	3.34647	150	5.90554	28	1.10236	3	0.12
218	90	3.54332	160	6.29924	30	1.18110	3	0.12
219	95	3.74017	170	6.69294	32	1.25984	3	0.12
220	100	3.93702	180	7.08664	34	1.33858	3	0.12
221	105	4.13387	190	7.48035	36	1.41732	3	0.12
222	110	4.33072	200	7.87405	38	1.49607	3	0.12

ANNULAR (RADIAL) BALL BEARINGS
S. A. E. Standard Sizes
MEDIUM SERIES

Bearing Number	B		D		W Of Individual Rings		Y Corner Radius	
	Mm.	Inches	Mm.	Inches	Mm.	Inches	Mm.	Inches
300	10	0.39370	35	1.37795	11	0.43307	1	0.04
301	12	0.47244	37	1.45669	12	0.47244	1	0.04
302	15	0.59055	42	1.65355	13	0.51181	1	0.04
303	17	0.66929	47	1.85040	14	0.55118	1	0.04
304	20	0.78740	52	2.04725	15	0.59055	1	0.04
305	25	0.98425	62	2.44095	17	0.66929	1	0.04
306	30	1.18110	72	2.83465	19	0.74803	2	0.08
307	35	1.37795	80	3.14962	21	0.82677	2	0.08
308	40	1.57481	90	3.54332	23	0.90551	2	0.08
309	45	1.77166	100	3.93702	25	0.98425	2	0.08
310	50	1.96851	110	4.33072	27	1.06299	2	0.08
311	55	2.16536	120	4.72443	29	1.14173	2	0.08
312	60	2.36221	130	5.11813	31	1.22047	2	0.08
313	65	2.55906	140	5.51183	33	1.29921	3	0.12
314	70	2.75591	150	5.90554	35	1.37795	3	0.12
315	75	2.95277	160	6.29924	37	1.45669	3	0.12
316	80	3.14962	170	6.69294	39	1.53544	3	0.12
317	85	3.34647	180	7.08664	41	1.61418	3	0.12
318	90	3.54332	190	7.48035	43	1.69292	3	0.12
319	95	3.74017	200	7.87405	45	1.77166	3	0.12
320	100	3.93702	215	8.46460	47	1.85040	3	0.12
321	105	4.13387	225	8.85830	49	1.92914	3	0.12
322	110	4.33072	240	9.44886	50	1.96851	3	0.12

ANNULAR (RADIAL) BALL BEARINGS
S. A. E. Standard Sizes
HEAVY SERIES

Bearing Number	B		D		W Of Individual Rings		Y Corner Radius	
	Mm.	Inches	Mm.	Inches	Mm.	Inches	Mm.	Inches
403	17	0.66929	62	2.44095	17	0.66929	1	0.04
404	20	0.78740	72	2.83465	19	0.74803	2	0.08
405	25	0.98425	80	3.14962	21	0.82677	2	0.08
406	30	1.18110	90	3.54332	23	0.90551	2	0.08
407	35	1.37795	100	3.93702	25	0.98425	2	0.08
408	40	1.57481	110	4.33072	27	1.06299	2	0.08
409	45	1.77166	120	4.72443	29	1.14173	2	0.08
410	50	1.96851	130	5.11813	31	1.22047	2	0.08
411	55	2.16536	140	5.51183	33	1.29921	3	0.12
412	60	2.36221	150	5.90554	35	1.37795	3	0.12
413	65	2.55906	160	6.29924	37	1.45669	3	0.12
414	70	2.75591	180	7.08664	42	1.65355	3	0.12
415	75	2.95277	190	7.48035	45	1.77166	3	0.12
416	80	3.14962	200	7.87405	48	1.88977	3	0.12
417	85	3.34647	210	8.26775	52	2.04725	3	0.12
418	90	3.54332	225	8.85830	54	2.12599	3	0.12
419	95	3.74017	250	9.84256	55	2.16536	3	0.12
420	100	3.93702	265	10.43311	60	2.36221	3	0.12

ANNULAR (RADIAL) BALL BEARINGS
S. A. E. Standard Tolerances
Standard bore tolerance in inches.

BORE		BEARING NUMBER			TOLERANCE	
Mm.	Inches	Light Series	Medium Series	Heavy Series	Plus	Minus
10 to 55 inc.	0.39370 to 2.16536 inc.	200 to 211 inc.	300 to 311 inc.	403 to 411 inc.	0.0002	0.0004
60 to 80 inc.	2.36221 to 3.14962 inc.	212 to 216 inc.	312 to 316 inc.	412 to 416 inc.	0.0002	0.0005
85 to 110 inc.	3.34647 to 4.33072 inc.	217 to 222 inc.	317 to 322 inc.	417 to 420 inc.	0.0002	0.0006

Standard outside diameter tolerance in inches.

OUTSIDE DIA.		BEARING NUMBER			TOLERANCE	
Mm.	Inches	Light Series	Medium Series	Heavy Series	Plus	Minus
30 to 47 inc.	1.18110 to 1.85040 inc.	200 to 204 inc.	300 to 303 inc.	....	0.0000	0.0005
52 to 140 inc.	2.04725 to 5.51183 inc.	205 to 216 inc.	304 to 313 inc.	403 to 411 inc.	0.0000	0.0008
150 to 265 inc.	5.90554 to 10.43311 inc.	217 to 222 inc.	314 to 322 inc.	412 to 420 inc.	0.0000	0.0012

Width tolerance in inches for individual race rings for all sizes of bearings to be plus 0.000 and minus 0.005 inch.

Standard eccentricity tolerance in inches.

BORE		BEARING NUMBER			TOLERANCE	
Mm.	Inches	Light Series	Medium Series	Heavy Series	Inner Race	Outer Race
10 to 20 inc.	0.39370 to 0.78740 inc.	200 to 204 inc.	300 to 304 inc.	403 to 404 inc.	0.0006	0.0012
25 to 40 inc.	0.98425 to 1.57481 inc.	205 to 208 inc.	305 to 308 inc.	405 to 408 inc.	0.0008	0.0012
45 to 75 inc.	1.77166 to 2.95277 inc.	209 to 215 inc.	309 to 315 inc.	409 to 415 inc.	0.0010	0.0016
80 to 110 inc.	3.14962 to 4.33072 inc.	216 to 222 inc.	316 to 322 inc.	416 to 420 inc.	0.0012	0.0018

This would result in the rejection of bearings which, if measured under proper temperature conditions, would come within limits. Likewise, a change in temperature of gages might for the same reason result in the rejection of the bearings. It is necessary, therefore, that care be exercised to maintain both bearings and gages at a uniform standard temperature during inspection, and in so far as possible during manufacture. In order to establish uniform practice and to safeguard the inspection and manufacture of bearings and to prevent unnecessary rejections the following is recommended:

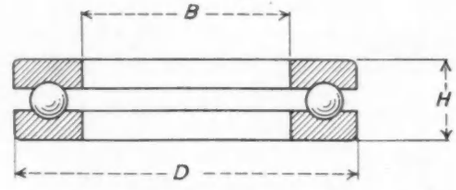
"These tolerances are applicable only when the bearings and measuring appliances have been brought to a uniform temperature, as for instance 68 deg. fahr. In case of question as to measurements, gages officially checked by the United States Bureau of Standards shall be considered as final. These tolerances are understood as referring to the dimensions of ball bearings, and not to the dimensions of measuring instruments. When it is desired to measure bearings by the use of maximum and minimum gages, the dimensions of the maximum gage shall be 0.0001 in. over the maximum bearing dimension, and the dimension of the minimum gage shall be 0.0001 in. under the minimum bearing dimension."

The above paragraph specifying the only temperature at which tolerances are applicable to bearings and measuring appliances applies both to annular (radial) ball bearing tolerances and thrust bearing tolerances.

3. *Definition of Eccentricity.*—The Division recommends that the present definition of eccentricity* accompany the tables of tolerances given below, and that the matter† relating to bore tolerances, axial freedom, short-type roller bearings and length of long ball and roller bearings be cancelled.

4. *Roller Bearings.—Metric Sizes. Progress Only.* The Division has learned that the Ordnance Department of the United States Army has had difficulty in interchanging straight roller bearings with certain taper roller bearings, owing to differences in fitting tolerances. Before action could be taken on this matter by the Division the Ordnance Department had straightened out its difficulties with the roller-bearing makers concerned, it is understood, by changing the S. A. E. tolerances so as to produce proper functioning of their bearings. When this matter was brought up at the Division meeting the question of revision of the present S. A. E. standards, with particular reference to tolerances, and the possibility of changing the title to be "Straight Roller Bearings," were also considered. This entire subject is in the hands of the Division for further action and consideration at an early date.

5. *Thrust Bearing Tolerances.*—Last year certain types of thrust ball bearings with dimensions given in inches were approved, and there has been considerable demand for not only these types, but also metric sizes, which it has not been possible to standardize as yet. However,



SINGLE DIRECTION THRUST BEARINGS—FLAT FACE TYPE
S. A. E. Standard Tolerances

BORE (*B*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 35	0.0000 to 1.3779	0.0008	0.0000
36 to 60	1.4173 to 2.3622	0.0010	0.0000
61 to 110	2.4016 to 4.3307	0.0012	0.0000

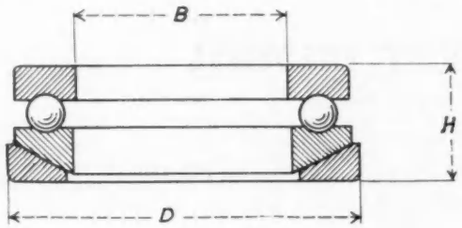
DIAMETER (*D*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 150	0.0000 to 5.9055	0.0000	0.0020
151 to 200	5.9449 to 7.8740	0.0000	0.0030

THICKNESS (*H*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 35	0.0000 to 1.3779	0.0020	0.0020
36 to 100	1.4173 to 3.9370	0.0030	0.0030

*The eccentricity of the inner race is that lack of running truth noticed upon the stationary outer race when rotating the inner race and balls upon true centers.

The eccentricity of the outer race is that lack of running truth shown upon a suitable indicator during the rotation of the outer race and balls upon the inner race fixed upon a stationary arbor.

†See S. A. E. Transactions, Vol. 9, Part I, p. 39; and S. A. E. Handbook, Vol. I, sh. 29c.

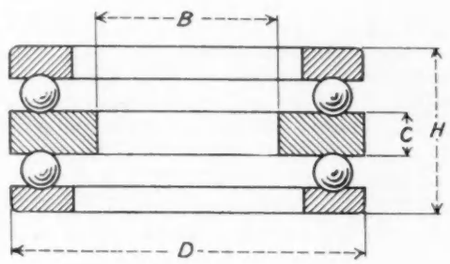


SINGLE DIRECTION THRUST BEARINGS WITH SELF-ALIGNING WASHERS
S. A. E. Standard Tolerances

BORE (*B*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 35	0.0000 to 1.3779	0.0008	0.0000
36 to 60	1.4173 to 2.3622	0.0010	0.0000
61 to 110	2.4016 to 4.3307	0.0012	0.0000

DIAMETER (*D*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 150	0.0000 to 5.9055	0.0000	0.0020
151 to 200	5.9449 to 7.8740	0.0000	0.0030

THICKNESS (*H*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 40	0.0000 to 1.5748	0.0030	0.0030
41 to 100	1.6142 to 3.9370	0.0040	0.0040



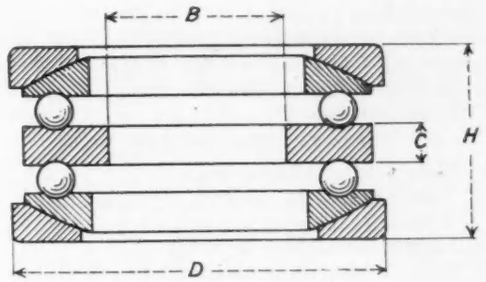
DOUBLE DIRECTION THRUST BEARINGS—FLAT FACE TYPE
S. A. E. Standard Tolerances

BORE (*B*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 35	0.0000 to 1.3779	0.0008	0.0000
36 to 60	1.4173 to 2.3622	0.0010	0.0000
61 to 110	2.4016 to 4.3307	0.0012	0.0000

DIAMETER (*D*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 150	0.0000 to 5.9055	0.0000	0.0020
151 to 200	5.9449 to 7.8740	0.0000	0.0030

THICKNESS (*H*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 75	0.0000 to 2.9528	0.0040	0.0040
76 to 150	2.9921 to 5.9055	0.0060	0.0060

THICKNESS (*C*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 10	0.0000 to 0.3937	0.0015	0.0015
11 to 20	0.4331 to 0.7874	0.0020	0.0020
21 to 35	0.8268 to 1.3779	0.0025	0.0025



DOUBLE DIRECTION THRUST BEARINGS WITH SELF-ALIGNING WASHERS
S. A. E. Standard Tolerances

BORE (*B*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 35	0.0000 to 1.3779	0.0008	0.0000
36 to 60	1.4173 to 2.3622	0.0010	0.0000
61 to 110	2.4016 to 4.3307	0.0012	0.0000

DIAMETER (*D*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 150	0.0000 to 5.9055	0.0000	0.0020
151 to 200	5.9448 to 7.8740	0.0000	0.0030

THICKNESS (*H*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 85	0.0000 to 3.3465	0.0060	0.0060
86 to 200	3.3858 to 7.8740	0.0080	0.0080

THICKNESS (*C*)		TOLERANCES, INCH	
Mm.	Inch	Plus	Minus
0 to 10	0.0000 to 0.3937	0.0015	0.0015
11 to 20	0.4331 to 0.7874	0.0020	0.0020
21 to 35	0.8268 to 1.3779	0.0025	0.0025

at the request of the English Committee, a great deal of time has been spent in considering tolerances for thrust ball bearings. The accompanying drawings and tables, are recommended for standardization.

While these series of thrust bearing sizes, in response to the general demand, are given in millimeters, the tolerances, given in inches, will probably fit the inch type of bearing, which unfortunately have not yet been translated into metric dimensions owing to lack of time.

REPORT OF DATA SHEET DIVISION

(As accepted for submission to mail vote.)

SEVERAL definite recommendations for increasing the usefulness of the S. A. E. Handbook as submitted by the Data Sheet Division, are presented below:

1. *New Size of Data Sheets.*—In reviewing the former recommendation to retain the present size of Handbook, the Division believes the advantages to be gained with the larger size sheet are considerably overbalanced by those for retaining the present size. The principal reasons considered are:

FOR THE 8½ BY 11-IN. SIZE

(a) Cuts could be made larger.
(b) There would be more space for lengthy specifications.
(c) Larger type could be used.
(d) The Handbooks would not be so thick.
(e) It would be possible to file letter-size drawings, etc., with the data sheets.

FOR RETAINING THE PRESENT SIZE

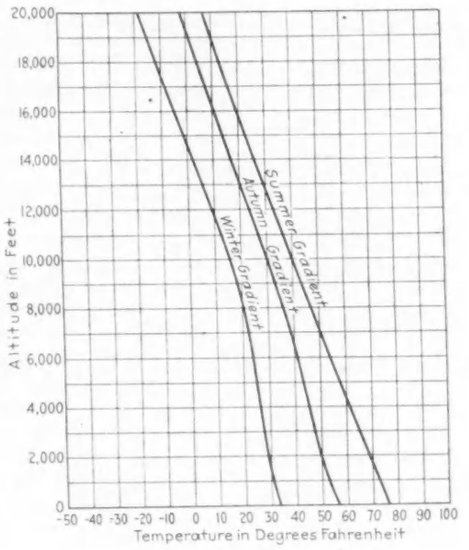
(a) Practically all cuts can be printed distinctly on present size sheet.
(b) There is no objection to printing lengthy specifications on two or more pages. Comparatively few tabulated specifications require more than one page, but when they do two pages facing each other can be used. This is in accordance with present practice.
(c) A satisfactory type size for both text and tabulated specifications is now being used.
(d) The thickness of the present Handbook is not objectionable.
(e) Handbooks are not intended for filing miscellaneous sheets.
(f) Larger books would take up too much desk or table room, especially if they are used generally.
(g) The change would be costly, and would cause inconvenience to members.

Therefore, the Division's recommendation that the present size data sheet (4¼ by 7¼ in.) be retained permanently has been approved.

2. *New Sheet Numbering System.*—The present system of numbering is inadequate to take care of the additions to the list of S. A. E. Standards and Recommended Practices. The "Dewey" decimal system is not sufficiently flexible or expansive. After considering several other possibilities the Division recommends the use of the following system:

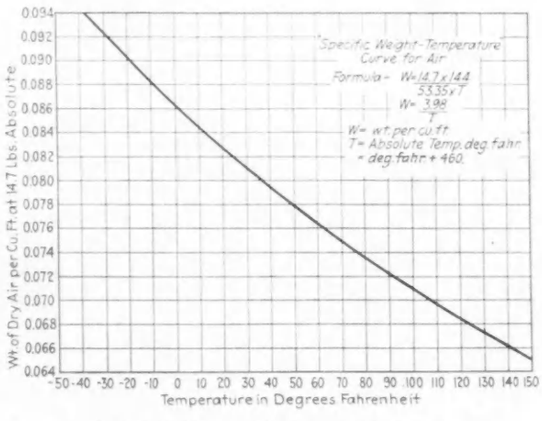
The sheet number will consist of three sets of figures, written on the same line and separated by dashes. The first set indicates the general subject group under which the sheet would naturally be classified. The second indicates the sheet number in that particular group. The third set indicates the number of the new sheet to be inserted after any one of the sheets of that particular group. This permits any number of new sheets to be inserted. As an illustration—under the subject of Screws and Bolts:

The first page figure under this subject would be 4. The data sheets on screws and bolts at present printed in the Handbook would then follow in their regular order and be numbered 4-1-0, 4-2-0, 4-3-0, etc. When a new data sheet is inserted, as after 4-2-0, it would be numbered 4-2-1. When a data sheet is revised the number remains the same and the word "Revised" with the date will be added after the footnote referring to the date of the original report as adopted by the Society. The date



TEMPERATURE-ALTITUDE CURVES

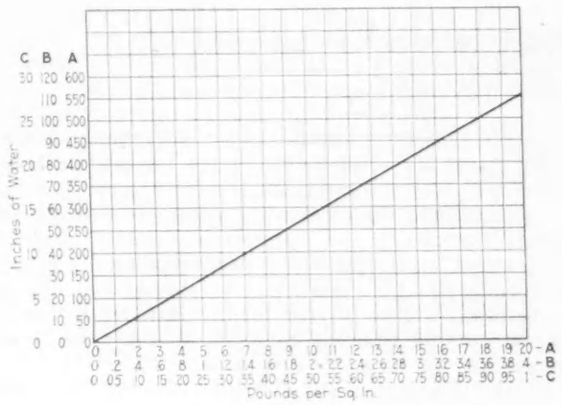
on which the revised sheet is printed will be indicated by the date under the emblem. A data sheet, when reprinted without any revision, will bear the same page number, and the only change will be the date under the emblem.



SPECIFIC WEIGHT-TEMPERATURE CURVE

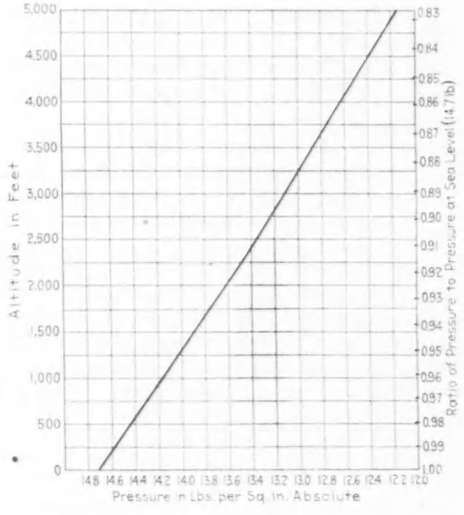
The Division believes the best time to put this system into effect will be after the war, as doing so before then would probably cause considerable inconvenience to the many users of these Handbooks in Government work.

3. *Classified Sectional Index.*—The Handbook will be of more use if it contains a classified sectional index as well as the alphabetical cross-index, for S. A. E. Standards and Recommended Practices only.



CURVE FOR CONVERSION OF INCHES OF WATER TO POUNDS PER SQUARE INCH

It is recommended that a classified sectional index for S. A. E. Standards and Recommended Practices be compiled and printed for the Handbook.



PRESSURE-ALTITUDE CURVE (FROM KENT)

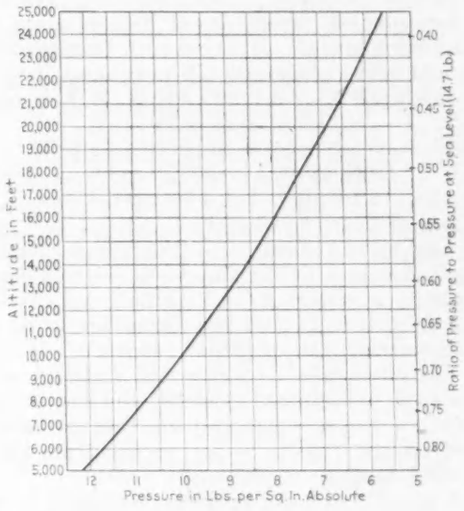
4. *Woodruff Key Tables.*—As Woodruff shaft keys are incorporated in some of the S. A. E. Standard specifications, it is thought desirable to have a complete table of them in the Handbook. Up-to-date drawings and tables of sizes have been arranged, to be printed in Vol. II.

5. *Curve Sheets.*—The following curve sheets are considered of sufficient value, particularly for carburetion work, to be printed in Vol. II of the Handbook:

(a) "Temperature—Altitude Curves." The data for these were taken from the Mount Weather Observatory Bulletin and are based on five years' average readings of temperatures. (b) "Specific Weight—Temperature Curves for Air." (c) "Conversion, Inches of Water to Pounds per Square Inch." (d) "Pressure—Altitude." The data for this curve were taken from the eighth edition of "Kent." Absolute pressures are given in pounds per square inch for altitudes from zero to 5000 feet. (e) "Pressure—Altitude." The data for this curve were taken from "Flight Manual," London, and give pressure in pounds per square inch absolute for altitudes from 5,000 to 25,000 feet.

These curves were secured through the courtesy of Hopewell Bros. Laboratory.

6. *Transferring Data Sheets.*—The Division recommends that all data sheets covering subjects other than S. A. E. Standards or S. A. E. Recommended Practices be transferred from Vol. I to Vol II. (This will not be done, however, until the new page numbering system is put into effect.)



PRESSURE-ALTITUDE CURVE (FROM FLIGHT MANUAL)

7. *Data Sheet Revision.*—Data Sheet 4b, Vol. I, shows strengths and dimensions of the S. A. E. standard screws and bolts listed on Data Sheet 4, Vol. I, and in order to make the heading definite the Division recommends that the title of Data Sheet 4b, Vol. I, be changed from "Dimensions and Strengths of Standard Bolts" to "Dimensions and Strengths of S. A. E. Standard Bolts."

NOTICE TO MEMBERS

DATA SHEET ERRATA

1. Data Sheet 8k, Vol. I. *Pneumatic-Tire Rim Sections.*
   In the cut of the "CC" Rim Section, the reference (I) applies to dimension, 1.65 in., (distance between clincher tips), instead of to dimension, 2.16 inches.
2. Data Sheet 8-l, Vol. I. *Wheel and Rim Specification.*
   In column "I" of the table the dimensions should be 1.65 in., 1.80 in., and 1.50 inches.
3. Data Sheet 56c, Vol. I. *Fuel and Lubrication Pipe Fittings.*
   In the second line at the top of the page, dimension 9/16 in. should be 9/16 inch.
4. Data Sheet 3b, Vol. II. *Circular Pitch.*
   The last two equations in the formula column should be respectively:
   $D=0.3183\ (N+2)\ P'$ and $D=D'+0.6366\ P'$
5. Data Sheet 3c, Vol. II. *Circular Pitch.*
   The last two equations in the formula column should be respectively:
   $$f = 0.05\,P' \text{ and } f = \frac{t}{10}$$

These data sheets will be corrected and sent to members with the Standards and Recommended Practices approved by the Standards Committee and Society in June, which will be published after the letter ballot of the Society is received.

REPORT OF ELECTRICAL EQUIPMENT DIVISION

(As accepted for submission to mail vote.)

1. *Starting Motor Pinion.*—Present practice in starting motor pinions varies in that they have from 9 to 13 teeth. As long as this variation exists, it is impossible for the engine designer to maintain gear centers and provide for complete interchangeability of starting motors of different makes. It is believed that the 11-tooth pinion would serve practically all purposes. In view of this, the following is submitted as S. A. E. Recommended Practice:

Flywheel starting motors shall be equipped with an 8-10 pitch, 11-tooth 20-deg. pressure angle, pinion wherever possible. The pitch line clearance between pinion and flywheel shall be 0.015 inch.

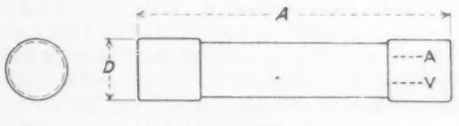
2. *Starting-Switch Location.*—The standardization of mounting dimensions of starting switches would necessitate completely new designs in practically all cases. The consensus of opinion is that the advantage to be gained would not warrant the necessary expense. It will be, however, an advantage to locate the starting switches on the car so as to facilitate assembly and chassis testing.

The Division recommends that starting switches shall be located on the chassis so as to facilitate electrical assembly and testing on chassis.

3. *Marking of Fuses.*—Considerable trouble is experienced with electric fuses which are made with glass tubes for use on gasoline automobiles, because there is no general method of marking their capacity, and paper labels will not stick on glass. The smallest standard fuse, marked under the National Electric Code of the National Board of Fire Underwriters, is 2 in. long with 9/16-in. diameter ferrules. Smaller fuses are considered special, and the National Board of Fire Underwriters recommends that all fuses, whether special or not, be marked with voltage and current capacity.

The Division recommends that fuses of the same dimensions as the National Electric Code fuses shall be marked according to the requirements of that code.

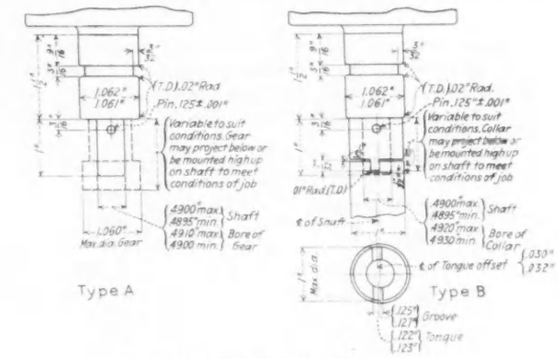
The Division recommends that the present marking instructions* be changed from "Fuses to be marked '25 volts,' and their carrying capacity," to read, "The voltage (*V*) and current capacity (*C*) shall be plainly marked on one of the ferrules of each fuse."



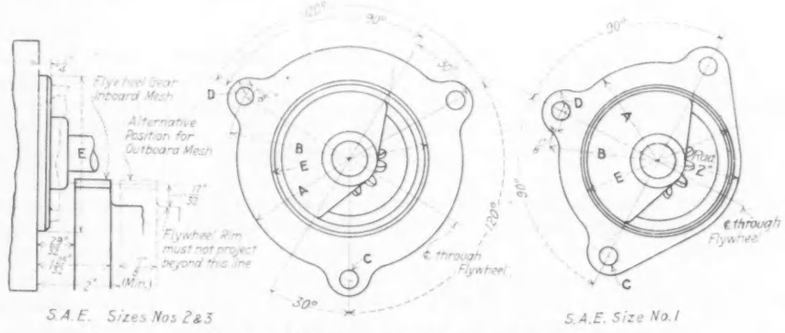
MARKING OF FUSES

4. *Ignition Distributor Mounting.*—The present standard* is not complete enough to be interchangeable for both generator and engine mounting. In order to secure this desired interchangeability for both generator and engine mounting, the present standard should include the shaft dimensions and methods of driving. Type A, for gear drive, and Type B, for tongue-collar drive, were worked out with the cooperation of engine and ignition manufacturers. The distributor mountings, shown on the accompanying drawing as Type A and Type B, are recommended for S. A. E. Standard.

5. *Flange Mountings for Starting Motors (Size Nos. 2 and 3).*—Present standard† flange mountings for starting motors are not extensively adopted, although many manufacturers have been using them. The position of the bolt holes, particularly of the bottom one, is inaccessible in many assemblies, and two settings of the facing tools are required to machine the mounting face on the engine. The present standard is also considered incomplete because the location of the pinion opening in the housing is not specified. As an amplification of the present standard, the following is recommended for S. A. E. Standard.



IGNITION DISTRIBUTOR MOUNTINGS


Flywheel Gear Inboard Mesh
Alternative Position for Outboard Mesh
Flywheel Rim must not project beyond this line
℄ through Flywheel
S.A.E. Sizes Nos 2&3
S.A.E. Size No.1

FLANGE MOUNTINGS FOR STARTING MOTORS

Note: All dimensions for Nos. 2 and 3 are S.A.E. Standard except for Pinion opening in Gear Housing.

The flange mounting for starting motors Nos. 2 and 3 shall be retained with the addition of pinion-opening location, as shown on the accompanying illustration.

*See S. A. E. Transactions, Vol. 9, Part I, pp. 7 and 8; Vol. 10, Part I, p. 25; and S. A. E. Handbook, Vol. I, sh. 48h.

*See S. A. E. Transactions, Vol. 12, Part II, pp. 33 and 34, and S. A. E. Handbook, Vol. I, sh. 36b.

†See S. A. E. Transactions, Vol. 12, Part II, p. 33, and S. A. E. Handbook, Vol. I, sh. 36d.

6. *New Flange Mounting for Starting Motors (New Size No. 1).*—No. 1 is a flange mounting for starting motors adaptable for use in marine work. This flange mounting will be applicable to present starting motor sizes also, and to types with geared outboard mesh which are difficult to get into position on the engine because of interference with the flywheel. The bolt holes in the new flange are so arranged as to overcome this objection to the present standard.

This is recommended for S. A. E. Standard.

Size No.	A	B	C	D	E
1	2 3/8	2 1/2	1 13/32	9/16	3.496 to 3.499
2	2 11/16	2 7/8	1 13/32	9/16	3.621 to 3.624
3	2 13/16	3 1/8	1 13/32	1 9/32	3.621 to 3.624

Dimensions for size No. 1 are the approved for standard

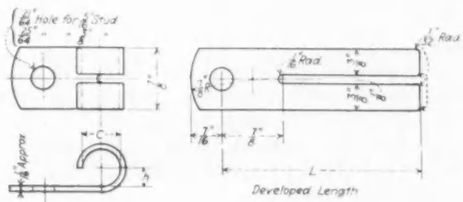
7. *Sleeve Type Starting Motor Mounting (Progress Report).*—This type of mounting has been in use for some time, and has many points of merit over the flange mounting. It eliminates the objectionable third bolt and simplifies the machining of the engine casting, at the same time making a strong assembly. It can also be used for generators, except that the sleeve should then be eccentric, to take up the slack for chain drives. This type of motor mounting is still before the Division.

8. *Generator Shaft-End for Coupling Drive.*—In order to include shaft-end dimensions for coupling drive for use with generators a single shaft-end is proposed; this conforms in general to the shaft-end now used on the No. 1 standard generator flange mounting for gear or chain drive,* but is somewhat shorter. This shaft-end is of ample capacity for all sizes of generators, except that in special instances small generators, naturally not suited to this proposed standard, may be fitted, in accordance with present practice, with the standard magneto shaft-end.

The recommendation for S. A. E. Standard is shown on the drawing of the generator bracket mounting, page 102.

9. *Cable Lengths and Terminals for Starting Motors.*—In order to unify the types and sizes of starting-motor cable terminals, the Division recommends the use of a single type terminal. The design conforms to the large majority of the terminals now in use. The great majority of terminal studs are 5/16 in. and 3/8 in. diameter, and most of the cable used is one of three sizes, SB-1, SB-0, SB-00. The proposed terminal can be adapted to any one of these, because it is punched and shaped to fit the largest cable; when assembled on the smaller cables, it is pinched down to fit the strands and the end of the insulation. With this terminal thorough and visible soldering can be had and it can be used for practically all conditions encountered in making connections.

The recommended S. A. E. Standard is: Starting-motor cable-terminals shall be of one type, about 1/16 in. thick, with two sizes of hole. For 5/16-in. studs the hole is to be 21/64 in. diameter, and for 3/8-in. studs the hole is to be 25/64 in. diameter, which allows 1/64 in. clearance for each size of stud. The accompanying illustration and table give the dimensions of the terminals and the approved cable sizes and lengths for 6 volt starting motor installations.

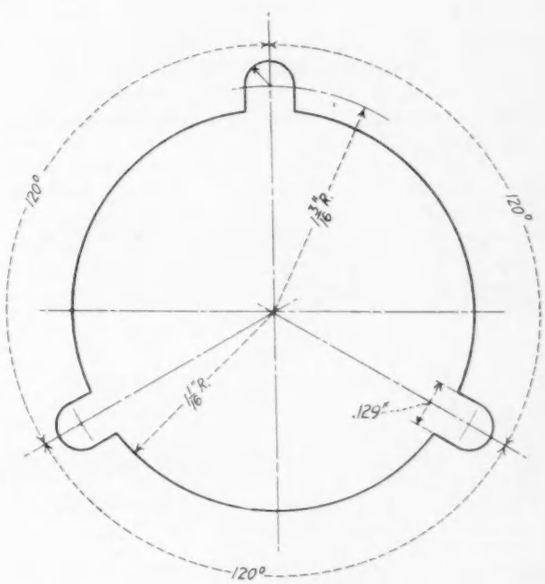


STARTING MOTOR CABLE TERMINALS

Cable Size	C	h	W	L	Max. Cable Length,—Ft.
SB-1.....	1 3/32	1 7/64	1 5/16	2 3/16	5
SB-0.....	1 9/32	1 9/64	2 3/32	2 5/16	7
SB-00.....	2 1/32	2 1/64	7/8	2 1/2	9

Dimensions in inches. "SB" indicates Single Braid.

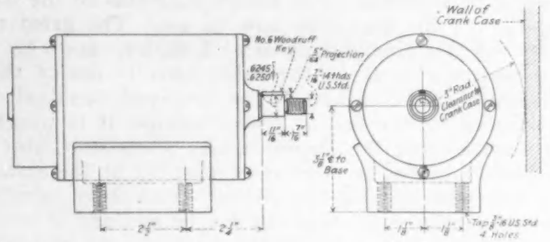
*See S. A. E. Transactions, Vol. 12, Part II, p. 32, and S. A. E. Handbook, Vol. I, sh. 36c.



INSTRUMENT MOUNTING DIMENSIONS FOR METAL DASH-BOARDS

A sub-committee of the Division is at work on terminals for ignition distributors, generators and switches, and the protection of terminals from surrounding metal parts.

10. *Instrument Mounting Dimensions for Metal Dash-Boards (Progress Report).*—The Division has found it impossible to standardize mounting dimensions for both large and small size instruments, but submits as of progress only the tentative mounting shown on the accompanying drawing for the small instruments. This mounting will accommodate the majority of small meters manufactured as well as the naval radial standard instrument. It is hoped that the use of this mounting will indicate during the next year the advisability of its adoption as a standard.



BRACKET MOUNTINGS FOR GENERATORS AND GENERATOR SHAFT-END FOR COUPLING DRIVE

11. *Bracket Mounting for Generators (Progress Report).*—There is no standard bracket-mounting for generators. Assemblies other than the standard flange mounting are not interchangeable for different sizes and makes of generators on different engines, which condition necessitates special assembling and needless manufacturing costs.

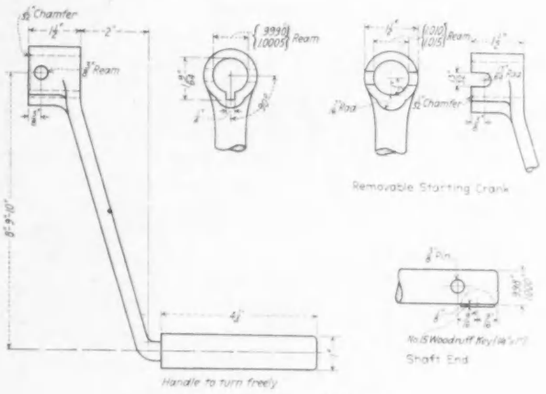
The generator manufacturers represented on the Division have signified their willingness to furnish bracket mountings for generators, which will fit a standard mounting pad on the engine, if the engine manufacturers will furnish such a pad.

The Engine Division is cooperating in this work and is preparing an engine-pad recommendation for use with the generator mounting dimensions proposed shown on the accompanying drawing. It is hoped that a definite proposal on this can be submitted in the near future.

REPORT OF ENGINE DIVISION

(As accepted for submission to mail vote)

1. *Hand Starting Cranks.*—At present there are many different attachment methods and shapes of hand starting cranks. If a shaft diameter and method of attachment for permanent and detachable cranks, and a definite crank offset are standardized practically all of the requirements will be met and an economic advance made. With this in view, the Engine Division has made a careful review of existing practice and submits the recommendation embodied in the accompanying drawing for S. A. E. Standard.



HAND STARTING CRANK

A review of the present engine shaft extensions indicates that 1 in. nominal diameter cold rolled steel with commercial limits +0.000, —0.002 inch. is a satisfactory dimension for practically all automobile and truck engines. A standard crank hub for either detachable or permanently attached cranks is secured by providing a key and pin, located in such a manner that either one or both can be used.

For the permanently attached crank, the shaft is provided with a No. 15 Woodruff key, and the 3/8-in. pin holds the crank in position, the location of the pin in the shaft being the same in either permanently attached or detachable crank. For the detachable crank the key is omitted and a 13/32-in. slot cut for pin engagement as shown on the drawing.

2. *Magneto Drive-Shaft and Coupling Dimensions.*—The nominal drive-shaft diameter and length, and the distance from the drive-shaft to the magneto shaft-end for tractor engines have already been standardized by the Society. In order to complete the present* standard, the following recommendation for S. A. E. Standard is made for Passenger Car, Commercial Vehicle and Marine Engines:

(a) The magneto drive-shaft shall be of selected cold-rolled stock, 3/4 in. nominal diameter. The diameter limits at the coupling end shall be 0.750 and 0.749 inches.

(b) Couplings for engine magneto drive-shaft shall have bore limits 0.7505 and 0.7495 in., and shall be held with a No. 8 Woodruff key, which is 5/32 in. thick and 3/4 in. long. The coupling manufacturer has an option of fastening his coupling with a taper pin or some clamping device, but the standard shaft-end will be 3/4-in. shaft with the No. 8 Woodruff key.

In placing the limits on coupling bores, it was ascertained that standard reamers have a tolerance of plus or minus 0.0005 inches.

It will be noted that a coupling with a 0.7495-in. bore is a press fit of 0.0005 in. on a shaft 0.750 in. diameter. This is the extreme case; it is not considered objectionable, and is preferable to a loose fit with a larger coupling bore.

3. *Thermostat Connections.* In view of the introduction of thermostats for controlling the circulating-water temperatures, and since there seems to be no uniformity in the methods of connecting such thermostats, the Engine Division recommends the following for S. A. E. Standard:

"All thermostats for insertion in the cooling system of internal combustion engines to control the temperature of the cooling-medium and having rubber-hose connections shall conform to S. A. E. standard sizes.†

When the connections are metallic, S. A. E. carbureter flanges‡ shall be used."

4. *Generator Bracket-Mounting Pads (Progress Report).*—In cooperation with the Electrical Equipment Division, general dimensions for a mounting pad on engines are now being formulated.

5. *Engine Support-Arms (Progress Report).*—Drawings showing existing practice are being carefully analyzed in order to obtain data for formulating a recommendation. This work is progressing satisfactorily.

*See S. A. E. Transactions, Vol. 8, Part I, pp. 23 to 25; Vol. 12, Part II, p. 13; and S. A. E. Handbook, Vol. I, sh. 36xa.

†See S. A. E. Transactions, Vol. 2, Part II, p. 17, and S. A. E. Handbook, Vol. I, sh. 37.

‡See S. A. E. Transactions, Vol. 10, Part II, p. 6, and S. A. E. Handbook, Vol. I, sh. 35.

PROGRESS REPORT OF THE IRON AND STEEL DIVISION

1. *Screw Stock.*—The American Society for Testing Materials has submitted to the S. A. E. two specifications for Bessemer and open hearth screw stock. The existing S. A. E. specification* and the two proposed by the A. S. T. M. are shown below in tabulated form:

Grade	Carbon Per Cent	Manganese Per Cent	Phosphorus Per Cent	Sulphur Per Cent
S. A. E. No. 1114.	0.08 to 0.20	0.30 to 0.80	0.12	0.06 to 0.12
A. S. T. M. Bessemer....	0.08 to 0.16	0.60 to 0.80	0.09 to 0.13	0.075 to 0.15
Open-hearth.	0.15 to 0.25	0.60 to 0.90	Not over 0.06	0.075 to 0.15

Copies of the A. S. T. M. recommendations have been sent to the members of the Division, and in general the replies indicate that the specification is acceptable. However, certain members are of the opinion that a maximum phosphorus content of 0.10 per cent would not be detrimental to open-hearth steel, that the manganese should be 0.30 to 0.80 per cent in both the open-hearth and Bessemer steels and that the sulphur in the open-hearth should be 0.06 to 0.12 per cent.

At the Iron and Steel Division meeting in Dayton, June 15, the members present carefully considered the subject, and suggested that the present S. A. E. specifications be revised and split into two separate specifications, one for Bessemer screw stock with the characteristic high phosphorous limit, and the other for open-hearth screw stock with the phosphorus content limited to 0.06 per cent maximum.

This Division is of the opinion that lower manganese limits are permissible and desirable. They do not interfere with the machining properties of the material and will help to conserve the manganese supply.

*See S. A. E. Transactions, Vol. 10, Part II, p. 22, and S. A. E. Handbook, Vol. I, sh. 9.

It is also the opinion of several members of the Division that the maximum sulphur limit should be decreased to safeguard against physical defects. The lower manganese limits proposed also make this reduction advisable. In view of this, the following limits were recommended:

	Carbon Per Cent	Manganese Per Cent	Phosphorus Per Cent	Sulphur Per Cent
Proposed S. A. E. Bessemer screw stock..	0.08-0.16	0.50-0.80	0.09-0.13	0.075-0.13
Proposed S. A. E. Open-hearth screw stock	0.15-0.25	0.50-0.90	Not over 0.06	0.075-0.12

As no quorum was present at this meeting, the Standards Committee, Council and Society passed the recommendation with the understanding that it should be approved by a majority of the Division and by the A. S. T. M. before becoming an S. A. E. Standard.

The specification was submitted to a joint meeting of the Iron and Steel Division of the Standards Committee of the Society and subcommittee No. XV of the Committee No. A1 on Cold Drawn Steel of the A. S. T. M., held on June 24, at Atlantic City.

It was the consensus of opinion of the members of this A. S. T. M. Subcommittee that a sulphur content of at least 0.09 per cent gave the highest mechanical qualities. Unless for special purposes, a sacrifice can be accepted in the machining qualities of such steel; no reduction should be made in the present maximum of 0.15 per cent sulphur. It was also the consensus of opinion that the present limits of 0.60 to 0.80 per cent manganese for Bessemer and 0.60 to 0.90 per cent for open hearth should remain.

In view of this situation, the subject is automatically referred back to the Iron and Steel Division.

REPORT OF TIRE AND RIM DIVISION

(As accepted for submission to mail vote)

THE Tire and Rim Division submits definite recommendations on the following subjects:

(a) Pneumatic-Tire Sizes, Passenger Cars and Commercial Vehicles.

(b) Rim Sections and Contours, Penumatic Tires for Passenger Cars and Commercial Vehicles.

(c) Valve Holes in Rims for Passenger Cars and Commercial Vehicles.

(d) Valve Holes for Motorcycle Rims.

(e) Carrying Capacities, Inflation Pressures for Automobile Pneumatic Tires.

(f) S. A. E. Deflection and Set Test of Rims for Automobile Pneumatic Tires.

(g) Wood Felloe Dimensions, Pneumatic-Tire Rims.

(h) Wood Spoke Dimensions, Commercial Vehicle Wheels.

This report is concluded by a proposed specification relating to tires and rims for airplane landing wheels, which at the present time is not submitted for definite action.

1. *Pneumatic-Tire Sizes—Passenger Cars and Commercial Vehicles.*—The possibility of reducing the number of tire sizes has been considered by the Tire and Rim Division for some time, but no agreement was reached until the Commercial Economy Board of the Council of National Defense requested that the subject be considered by the War Service Committee of the Rubber Industries of the U. S. A.

Accordingly, this War Service Committee met on April 2, 1918, at Akron, Ohio, following a meeting at the same place and day of the Tire and Rim Association. At the latter meeting tabulated data were presented showing the different sizes now being manufactured and stocked.

The first step was to select a simplified series of sizes that would take care of the greater part of the present demand. This series was analyzed from an engineering standpoint to determine if it were adequate for the service, and if the sizes in it could be reduced still further.

As a result, the War Service Committee recommended that the simplified list be divided into five classes, that

the production of sizes listed in the first four classes be discontinued on the dates given, and that only the sizes in the fifth (Class A) be produced after November, 1920. The simplified list is as follows:

Class E. The production of all sizes and types of tires not mentioned in any of the following four classes shall be discontinued at once.

Class D. List of tire sizes, production to be discontinued November, 1918.

Clincher (Non-Skid)	Straight Side	
32x3½ 33x4	30x3½ Non-skid 35x4 Non-skid 29x4½ Non-skid	36x4½ Plain 37x4½ Non-Skid 33x5 Plain

Q. D. Clincher (Non-Skid)	
32x3½ 33x4 32x4½	33x4½ 34x4½ 36x4½

Class C. List of sizes, production to be discontinued November, 1919.

Clincher	Straight Side	Q. D. Clincher (Non-Skid)
None	33x4½ Plain 36x4½ Non-skid	35x4½ 37x5

Class B. List of sizes, production to be discontinued November, 1920.

Clincher	Q. D. Clincher
30x3 Plain and Non-skid	35x5 Non-skid

Straight Side	
32x4 Plain and Non-skid 34x4 Plain and Non-skid 32x4½ Plain and Non-skid 33x4½ Non-skid	35x4½ Plain and Non-skid 33x5 Non-skid 37x5 Non-skid

Class A. List of sizes to be continued in production after November, 1920. (Future S. A. E. standard.)

Clincher (Plain and Non-Skid)	Straight Side (Plain and Non-Skid)	
30x3½ 31x4	32x3½ 33x4 34x4½ 35x5	36x6 38x7 40x8

The foregoing recommendations have been approved by the War Service Committee of the Rubber Industries of the U. S. A., the Tire and Rim Association, the board of directors of the National Automobile Chamber of Commerce. The Tire and Rim Division of the Standards Committee has approved the general work of the War Service Committee, and the Division recommends that the sizes in the Class A list be S. A. E. Standard, this list to supersede the present* recommended practice.

The recommendation of the Division, as presented in the accompanying table, includes inch dimensions for oversize tires and tire-seat diameters, together with the corresponding metric dimensions. It is recommended that manufacturers use as original equipment the nominal tire and rim sizes, thus permitting the use of the oversize equipment given.

Proposed Standard Pneumatic Tires and Rims for Passenger Cars and Commercial Vehicles

Nominal Tire and Rim Sizes		Oversize Tire		Tire-Seat Dia. (Rim)		Type of Rim
Inches	Mm.	Inches	Mm.	Inches	Mm.	
30x3½	90/585	31x4	105/585	23	585	clincher
32x3½	90/635	33x4	105/635	25	635	straight side
33x4	105/635	34x4½	120/635	25	635	straight side
34x4½	120/635	35x5	135/635	25	635	straight side
36x6	150/610	38x7	175/610	24	610	straight side
38x7	175/610	40x8	200/610	24	610	straight side
40x8	200/610	.....	.....	24	610	straight side

Note.—In inch nomenclature, nominal tire diameter = tire seat diameter + twice tire cross-section diameter. Sizes are designated by giving outside diameter of tire and tire-section diameter, as (30x3½).

In metric nomenclature, the nominal diameter = tire-seat diameter. Sizes are designated by giving tire cross-section diameter and tire-seat diameter. When spoken, the size is referred to as "90 for 585"; but is branded as 90/585.

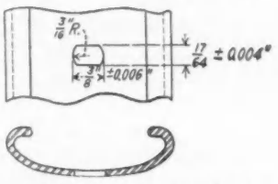
The adoption of this standard list of sizes cancels the present list* of tire sizes.

2. *Rim Sections and Contours, Pneumatic Tires for Passenger Cars and Commercial Vehicles.*—The rim and contour dimensions given in the following table and drawings are proposed for S. A. E. Standard as applying to the tire sizes suggested for standardization. The thickness of straight-side rims is not specified because it depends upon the steel composition and hardness, which have not been standardized, but are required to conform to S. A. E. Deflection and Set Test of Rims. This dimension is left to the judgment of the rim manufacturers in present practice. (See par. No. 7.)

3. *Valve-Hole Size, Automobile Rims.*—The Division recommends that the valve hole in rims for the proposed standard tire sizes shall be ⅜ in. diameter up to 6 in. rim inclusive. That this conforms with existing practise is shown by the following table:

Present practice, valve-hole diameters	1/4	11/32	3/8	7/16	31/64	9/16 or 37/64
Manufacturers using each size	1	2	4	5	2	1

4. *Valve-Hole Size, Motorcycle Rims.*—The valve hole in both the BB and CC types of motorcycle rims has been found to average ⅜ by 17/64 inches. This size has therefore been adopted for the U. S. military motorcycle. The



Motorcycle Valve Hole

The valve hole is located in the center of the rim and midway between two adjacent spoke holes

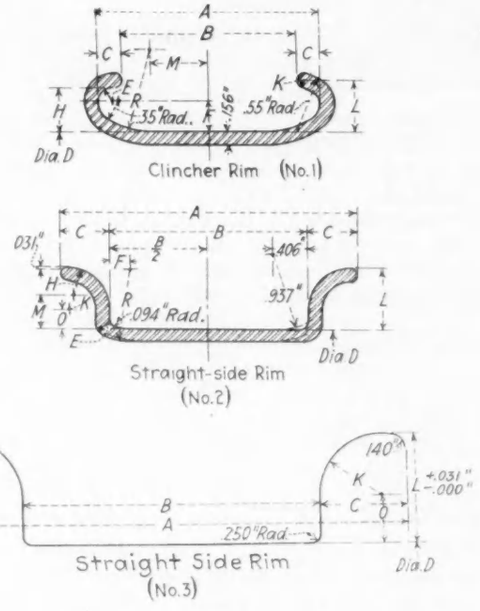
Division recommends that the dimensions and tolerances be as shown on the accompanying drawing for S. A. E. Standard.

5. *Carrying Capacities, Inflation Pressures, for Automobile Pneumatic Tires.*—The present recommended carrying capacities and inflation pressures† apply to sizes

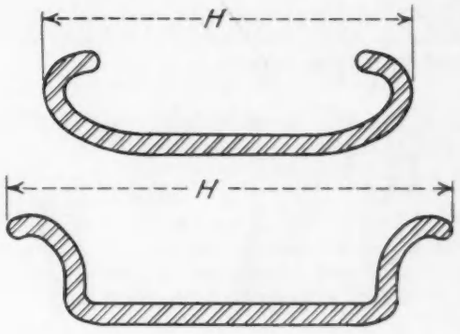
*See S. A. E. Transactions, Vol. 10, Part II, p. 9; The Journal, Vol. II, p. 99, and S. A. E. Handbook, Vol. I, sheet 8g.

*See S. A. E. Transactions, Vol. 10, Part I, p. 9, The Journal, Vol. II, p. 99; and S. A. E. Handbook, sh. 8g and 8o.

†See S. A. E. Transactions, Vol. 12, Part II, p. 69; and S. A. E. Handbook, Vol. I, sheet 8h.



RIM SECTION AND CONTOURS FOR PNEUMATIC TIRES



SECTIONS FOR DEFLECTION AND SET TEST RIMS

quick-detachable clincher rims is being discontinued the Division recommends that the following obtain for S. A. E. Standard:

"The recommended 'S. A. E. Deflection and Set Test' of rims is a pressure test with predetermined deflection under predetermined pressure. The test is made with water pressure.

"The measurements of deflection for either a clincher or a straight-side rim should be made across the extreme width, as shown by *H* on the accompanying illustration.

PROPOSED STANDARD PNEUMATIC TIRE RIM SECTIONS AND CONTOURS FOR PASSENGER CARS AND COMMERCIAL VEHICLES

Draw No.	Nominal Tire and Rim Size	Rim Dia. (*D*)	Rim Circum.* (Tire Seat)	Rim, Type	*A*	*B* ±0.047	*C*	*R*	*E*	*F*	*H*	*K*	*L*	*M*	*O*
1	30x3½	23	72.257		2.600	2.050	0.275	0.910	0.1400	0.3400	0.50	0.0780	0.5780	0.680	.....
2	32x3½	25	78.540		3.432	2.312	0.560	0.840	0.1875	0.2500	0.32	0.5100	0.6870	0.367	0.1990
	33x4	25	78.540		3.888	2.688	0.600	0.840	0.1875	0.2500	0.34	0.5600	0.7800	0.440	0.2450
	34x4½	25	78.540		4.380	3.120	0.630	1.095	0.1875	0.3125	0.38	0.6150	0.8750	0.495	0.3030
3	36x6	24	75.398		6.330	4.330	1.000	.....	.....	.....	....	0.7187	1.2656	.....	0.5469
	38x7	24	75.398		7.000	5.000	1.000	.....	.....	.....	....	0.7187	1.2656	.....	0.5469
	40x8	24	75.398		8.500	6.000	1.250	.....	.....	.....	....	0.8750	1.5000	.....	0.6250

*Tolerance for rim circumference, ±0.047 in. All dimensions given in inches.

from 3 to 6 in. inclusive. It is recommended that the following values for 7 and 8-in. tires be added to the present S. A. E. Standard, the values being recommended by the Tire and Rim Association:

Size of Tire In.	Size of Tire Mm.	Maximum Load, Pounds	Inflation Pressure, Pounds
7	175	2700	100
8	200	3650	110

6. *Motorcycle Tire Capacities and Pressures.*—The Division recommends that the carrying capacities and inflation pressures for motorcycle tires to be adopted by the Tire and Rim Association (probably on July 12, 1918) be adopted by the Society as S. A. E. Standard.

7. *S. A. E. Deflection and Set Test of Rims for Automobile Pneumatic Tires.*—The method of making this test* has previously been approved, but since the use of

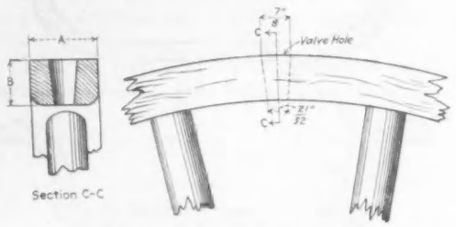
"Deflection should be measured from a fixed inflation load of 25 lb. per sq. in. for 3½, 4 and 4½-in. sections, and 50 lb. per sq. in. for 6-in. sizes and larger, up to a predetermined maximum, as follows:

Rim Size Nominal, Inches	Pressure, Pounds	Maximum Deflection, Inches	Total Permanent Set, Inches
3½	140	0.06	0.02
4	160	0.07	0.03
4½	180	0.10	0.06
6	200	0.15	0.06
7	200	0.15	0.06
8	Yet	to be	determined

"In conducting the tests, measurements of deflection should be made after load increments of 25 or 50 lb. as above are added; at a corresponding set the load should be released."

*See S. A. E. Transactions, Vol. 9, Part II, pp. 25-31 incl.; and S. A. E. Handbook, Vol. I, sheet 8f.

8. *Wood Felloe Dimensions, Pneumatic Tire Rims.*—The following dimensions* for wood felloes are recommended for S. A. E. Standard, the missing values to be submitted in a later report:



WOOD FELLOE DIMENSIONS

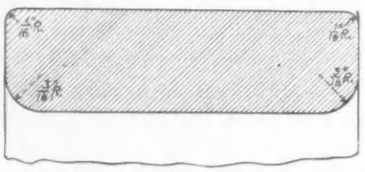
Nominal Tire and Rim Sizes	Widths (A)	Depths (B)
30x3½	....	....
32x3½	....	....
33x4	....	....
34x4½	....	....
36x6	3¼	1¾ ± 1/16
38x7	3 29/32	1¾ ± 1/16
40x8	4¼	1¾ ± 1/16

All dimensions in inches.

Valve hole in wood felloe for demountable rims to be 21/32 in. diameter on inside of felloe, and ⅞ in. on outside. Valve holes in wood felloe for detachable and plain clincher rims to be same diameter as valve hole in steel rim.

9. *Simplification of Solid Tire Sizes (Progress Report).*—As this subject is being worked on by the Technical Committee of the Rubber Industries with the cooperation of the Economy Division of the War Industries Board, this report is printed as of progress only until further data are secured.

10. *Edge of Felloe Bands.*—The Division's recommendation has been approved to change the paragraph under "Edges of Felloe Bands" Data Sheet 8 xb, Vol. I, to read as follows: "Bands to be rounded on two outside edges with radius not to exceed 1/16 in. (1.6 mm.) and on both inside edges with a radius of 3/16 in. (4.76 mm.)."



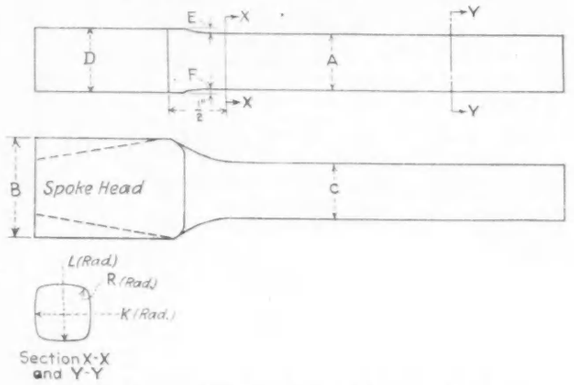
EDGES OF FELLOE BANDS

This change is desirable as wheel makers state that band makers are not using the 45-deg. chamber as at present specified, and that the revised specification will conform to present practice.

11. *Allowable Tolerances in Felloe Bands.*—The Division recommends that the present specifications† be changed to read as follows: "Allowable Tolerances in Felloe Bands—Width of band is to be + 1/32 in. (0.79 mm.) — 1/32 in. (0.79 mm.)."

In order to specify a more nearly commercial tolerance for bands, the following revision of present practice† is proposed: "Radial deviations must not occur at diametrically opposite points and there must be no flat spots or kinks in band on finished wheel. Either side of the band when laid down on a surface plate must not clear more than 1/32 in. at any point."

12. *Wood Spoke Dimensions, Commercial Vehicle Wheels.*—Over sixty different sizes and shapes of barrel until recently were in use by wood wheel manufacturers.



WOOD SPOKES FOR COMMERCIAL VEHICLE WHEELS

The spoke sizes* listed in the accompanying table are recommended for S. A. E. Standard. They have been adopted by practically all of the wood wheel manufacturers, and are already in use by over 80 per cent of all truck manufacturers. Some one of them is believed adequate for any size of wheel.

PROPOSED STANDARD SPOKE DIMENSIONS FOR COMMERCIAL VEHICLE WOOD WHEELS

Spoke Symbol Numbers	Nominal Spoke Size Thickness Between Flanges (D)	Size of Finished Barrel A	B	C	E	F	K	L	R	Max. Flange Diameter 12 Spokes	14 Spokes	16 Spokes
1425	1½	1⅜	2⅝	1⅜	1/4	1/4	3 1/16	3½	5/16	9½	11	12½
1625	1⅝	1⅝	2⅝	1⅝	1/4	1/4	2 15/16	2 15/16	5/16	10	11½	13¼
2026	2	2	2⅝	2	1/4	1/4	5/16	5/16	5/16	10	11½	13¼
2230	2¼	2¼	3	2¼	5/32	5/32	3 11/16	3 11/16	3/8	10¾	12½	14¼
2430	2½	2½	3	2½	5/32	5/32	3 5/16	3 5/16	3/8	10¾	12½	14½
2632	2¾	2¾	3½	2½	5/32	5/32	3½	10¾	3/4	11¼	13½	15½
3032	3	3	3½	2½	5/32	5/32	3½	10¾	3/4	11¼	13½	15½
3132	3½	3½	3½	2½	5/32	5/32	7½	10¾	5/16	11¼	13½	15½
4032	4	4	3½	3	5/32	5/32	7¼	12⅜	3/8	11¾	13½	15½
4432	4½	4½	3½	3	5/32	5/32	7¼	12⅜	3/4	11¾	13½	15½
5032	5	5	3½	3	5/32	5/32	10½	17 5/16	½	11¾	13½	15½

The first two figures of the symbol number indicate the finished size of barrel (thickness between flanges); and the second two figures indicate the dry width of head. The first figure of each pair indicates whole inches, and the second indicates eighths of an inch; thus, 1425 indicates 1⅜-in. barrel and 2⅝-in. head.

NOTE.—Radial allowance above flange diameters.

⅛ in., up to and including 9-in. flanges. 3/16 in., from 9 in. to 11½-in. flanges. ¼ in., above 11½ in. flanges.

This recommendation conforms with the Standard spokes for wood truck wheels adopted by the Automotive Wood Wheel Mfrs. Assoc., Feb. 20, 1918.

PROGRESS REPORT ON AIRPLANE LANDING WHEELS

13. *Tires and Rims.*—This subject is reported as one of progress only. The data below were worked out by a subcommittee of the Aeronautic Division. The Tire and Rim Division will check over these data, work in cooperation with Professor McGregor for the United States Government, and submit recommendations later.

The specification, as submitted below, covers the general requirements of tires and tubes for airplane landing wheels, it being the aim to confine the number of sizes to as few as possible. Larger sizes than listed below will probably be required, and the proposed speci-

*These were recommended by the Automotive Wood Wheel Mfg. Ass'n and have been adopted by the Tire and Rim Ass'n.

†See S. A. E. Transactions, Vol. 8, Part II, p. 53, and S. A. E. Handbook, Vol. I, sh. 8a.

*These recommendations conform with the standard spokes for wood truck wheels adopted by the Automotive Wood Wheel Mfg. Ass'n.

fication will be extended to include these sizes as soon as demanded.

All tires and tubes shall be free from defective material and workmanship, and shall conform to the following general construction, limits and tests:

Tires shall be of the clincher type, smooth tread, constructed of two or more cord plies of long staple cotton, so arranged that an equal number of plies run in each diagonal direction across the tire. Each ply shall be separated from the adjoining ply by rubber compound. Enough rubber compound must be put on side wall to insure ample protection of tire body. The tread stock shall have a minimum specific gravity of 1.30. The inside of tires need not be painted.

Tire beads shall be constructed so as to insure against pinching and to properly fit the rim contours shown in accompanying drawing and table.

The dimensions and weights of the finished tires shall be according to the following table and within the limits specified:

TIRE DIMENSIONS AND WEIGHTS

	Dimensions				Weights†	
	Size		Thickness		Max.	Min.
	Tire*	Rim No.	Tread, Min.	Side-wall, Max.		
Millimeters Inches (approx.)	75/700 28x3	U_3	1.588 1/16	0.794 1/32	2.410 kg. 5 lb. 5 oz.	2.123 kg. 4 lb. 11 oz.
Millimeters Inches (approx.)	100/700 28x4	Z_2	2.381 3/32	1.191 3/64	4.137 kg. 9 lb. 2 oz.	3.851 kg. 8 lb. 8 oz.
Millimeters Inches (approx.)	125/750 30x5	Z_2	2.381 3/32	1.191 3/64	4.989 kg. 11 lb. 0 oz.	4.650 kg. 10 lb. 4oz.
Millimeters Inches (approx.)	150/800 32x6	Z_2	3.175 1/8	1.191 3/64	6.002 kg. 13 lb. 4 oz.	5.615 kg. 12 lb. 6 oz.

*Section widths and tire diameters when inflated 50 lb. per sq. in. shall not vary more than 4 per cent over or more than 2 per cent under nominal specified tire sizes.

†Weight without flap.

14. *Marking.*—Each tire shall be branded with the manufacturer's name, size, serial number, and rim number the tire is intended to fit.

15. *Tubes.*—Tubes shall be constructed of rubber compound to dimensions, weights and tolerance given in table, and shall withstand physical tests specified.

TUBE DIMENSIONS AND WEIGHTS

	Tire Size	Mandrel Diam., Min.	Wall Thickness, Min.	Weight* Approx.	Specific Gravity, Max.
Millimeters Inches (approx.)	75/700 28x3	47.63 1 7/8	1.194 0.047	0.4536 kg. 1 lb. 0 oz.	1.25 1.25
Millimeters Inches (approx.)	100/700 28x4	60.33 2 3/8	1.372 0.054	0.6804 kg. 1 lb. 8 oz.	1.25 1.25
Millimeters Inches (approx.)	125/750 30x5	76.20 3	1.575 0.062	0.9355 kg. 2 lb. 1 oz.	1.25 1.25
Millimeters Inches (approx.)	150/800 32x6	82.55 3 1/4	1.575 0.062	1.1911 kg. 2 lb. 10 oz.	1.25 1.25

*It is suggested that the maximum and minimum weights be specified for tubes as well as for the tires.

16. *Tube Tests.*—Tubes must withstand the water test mentioned under tire test, and shall have the following physical properties:

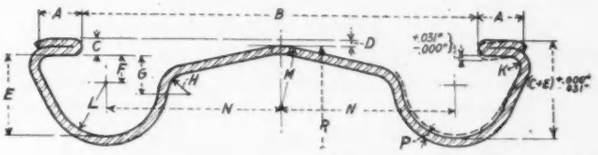
Minimum tensile strength.....1500 lb.
Minimum stretch..... 600 per cent
Maximum set (2 minutes after rupture)... 25 per cent

17. *Valve.*—The valve to be used will be of the bent type with adapter for American and foreign pumps.

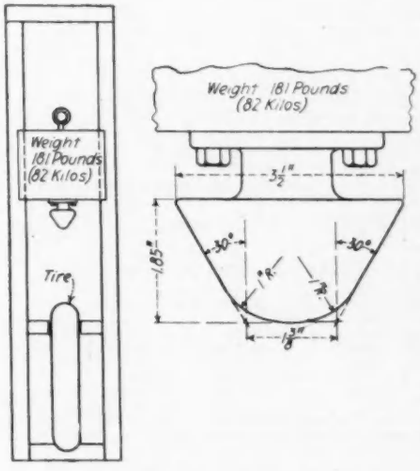
Tire and Tube Tests Combined

The manufacturer shall make a sufficient number of tests on the tires and tubes coming through production to satisfy himself that the product satisfies the requirements of this specification.

18. *Impact Test.*—The tire is mounted with the tube on a special rim of standard contour that will withstand the pressures given in the table. The tube is inflated with air and maintained at a pressure of 150 lb. per sq. in. In this condition the tire must withstand a blow delivered on the tread by a weight of 181 lb. (82 kg.), having a contact surface as indicated in the diagram, and falling through the distance indicated in the following table:



CROSS SECTION OF LANDING-WHEEL RIM



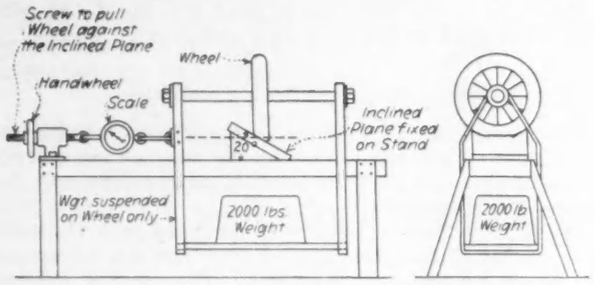
IMPACT TEST FOR PNEUMATIC TIRES

General Arrangement of Apparatus shown on Left. Detail of Contact Head shown on Right

Tire Size, Mm.	Drop (181 Lb. Weight)	
	In Inches	In Mm.
75/700	45	1143
100/700	55	1397
125/750	55	1397
150/800	55	1397

19. *Water-Pressure Test.*—All airplane tires from 75/700 to 150/800 mm. inclusive, when mounted on special rim, standard contour, shall withstand a water test of 200 lb., pressure not to be raised at a rate exceeding 50 lb. per minute.

20. *Side-Thrust Test.*—All airplane tires, from 75/700 to 150/800 mm. inclusive, when mounted on standard



AIRPLANE LANDING WHEEL SIDE-THRUST TEST
The Center Line of the Screw (Line of Pull) Should Come at the Point of Contact of the Tire with the Inclined Plane

rims, inflated to 50 lb. air pressure, and loaded with a dead weight of 2000 lb., shall withstand 1800 lb. lateral stress against a surface placed at an angle of 20 deg. with the horizontal, as shown in the illustration, without pulling off the rim.

21. *Landing-Wheel Rims.*—The accompanying table shows the proposed landing-wheel rim dimensions. Additional inspection requirements, besides those indicated by the table, are that the rim out-of-flat shall not exceed 1/16 in. when free on surface plate; rim tolerance for out-of-round is 3/32 in.; buckled rims are covered by the surface-plate inspection and tolerance limits; rims must be free from defective welds.

TABLES OF AIRPLANE LANDING-WHEEL RIM DIMENSIONS
In Inches

Rim Size	Tire Size		A +0.031 −0.000	B ±0.046	C +0.021 −0.006	D ±0.016	E	F	G	Radii				N	P	Diam. R	Circum.* (π R.)
	Mm.	Inch (Approx.)								H	K	L	M				
U_3	75/700	28x3	1 3/64	1 39/64	0.104	0.049	27/64	13/64	0.159	1/4	0.039	5/32	19/64	45/64	0.052	21 23/64	67.201
U_4	60/575 75/600	23x2½ 24x3	1 3/64	1 39/64	0.104	0.049	27/64	13/64	0.159	1/4	0.039	5/32	19/64	45/64	0.052	18 1/64	56.598
Z_{4a}	100/700 125/750	28x4 30x5	5/16	2 11/16	0.104	0.042	9/16	5/16	0.266	5/16	3/64	3/8	1/2	1 3/16	0.078	20 5/32	63.323
Z_3	150/800	32x6	5/16	2 11/16	0.144	0.082	9/16	5/16	0.266	5/16	3/64	3/8	1/2	1 3/16	0.094	20 5/32	63.323

*Tolerance from Nominal after Lacing +0.000 to −3/64 in.

In Millimeters

Rim Size	Tire Size		A +0.787 −0.000	B ±1.168	C* +0.533 −0.152	D ±0.406	E	F	G	Radii				N	P	Diam. R	Circum.* (π R.)
	Mm.	Inch (Approx.)								H	K	L	M				
U_3	75/700	28x3	5.156	40.868	2.642	1.245	10.719	5.156	4.039	3.175	0.991	5.563	7.544	17.856	1.321	543.330	1706.903
U_4	60/575 75/600	23x2½ 24x3	5.156	40.868	2.642	1.245	10.719	5.156	4.039	3.175	0.991	5.563	7.544	17.856	1.321	457.606	1437.587
Z_{4a}	100/700 125/750	28x4 30x5	7.950	68.273	2.642	1.067	14.300	4.775	6.756	4.775	1.981	9.525	12.700	30.174	1.981	511.962	1603.402
Z_3	150/800	32x6	7.950	68.273	3.658	2.083	14.300	4.775	6.756	4.775	1.981	9.525	12.700	30.174	2.388	511.962	1603.402

*Tolerance from Nominal after Lacing +0.000 to −1.981 mm.

REPORT OF THE TRACTOR DIVISION

(As accepted for submission to mail vote)

THE Tractor Division submits the following several recommendations:

1. *Speed and Widths for Power Belts and Pulleys.*—As a result of an investigation of present practice it has been found that three pulley widths will satisfy practically all needs. The Division had formerly recommended* that a belt speed of 2600 ft. per min. be used for all tractors. This action is incorporated in the following, recommended for S. A. E. Standard, as are also figures for pulley and belt widths:

"Tractors shall be equipped with pulleys giving a belt speed of 2600 ft. per min. at the crown of the pulley. The pulleys shall be as large as possible, and the widths vary according to the horsepower delivered, as shown in the following table:

Horsepower	Pulley Widths, In.	Max. Belt Widths, In.
Under 20	6½	6
20 to 30 inc.	7½	7
Above 30	To be determined	

It is intended that the maximum belt widths shall be ½ in. less than pulley widths.

Screws and Bolts.—A simplified series of bolts and screws will be of value both to the farmer in maintaining his tractor and to the manufacturer in lessening the number of such parts he must carry in stock.

*See S. A. E. Transactions, Vol. 9, Part II, pp. 25-31 incl.; and S. A. E. Handbook, Vol. I, sheet 8f.

The Division believes that the 1/16-in. steps above ½-in. bolt and screw diameters can be eliminated. In order to meet the requirements of the industry the following is proposed as S. A. E. Recommended Tractor Practice:

"In tractor engines S. A. E. Standard screws for tapped holes shall be used, except in soft material, such as cast-iron, brass, bronze or aluminum, in which the U. S. standard screws will be used.

"In general tractor construction bolts and screws of the U. S. or S. A. E. standard pitches, with square or hexagon heads, shall be used. They shall be limited to ⅛-in. steps about ½-in. diameter, and 1/16-in. steps below ½-in. down to and including ¼-in. diameter."

2. *Carbureter Flanges.*—Oversize carbureter flanges, not listed as S. A. E. standard, are being used on tractor engines, and these flanges have not been made according to any definite practice. In order to establish such a practice and to promote the progress of the carbureter art, the following is proposed as S. A. E. Recommended Tractor Practice:

All oversize carbureters shall be equipped with the S. A. E. standard flange, which is the next size larger than the flange standardized for the nominal carbureter opening. (Applying this to a 1⅜-in. carbureter, the flange should be the same as that used for the 1½-in.)

3. *Use of Existing Standards.*—The following standards are approved as S. A. E. Recommended Tractor Practice:

	S. A. E. Trans.	S. A. E. Handbook
Rod Ends	Vol. 12, Part II, pp. 45, 46 and 47	Vol. I, sh. 1, 1a, 2.
Rod-end Pins	Vol. 12, Part II, p. 44	Vol. I, sh. 2a.
Cotter Pins	Vol. 12, Part II, p. 45	Vol. I, sh. 2b.

The following S. A. E. steels are recommended for tractor practice:

No. 1020, for all ordinary hot and cold-rolled shafting, gear blanks and shapes; also for cold-rolled bars for general use.

No. 1045, for all hot and cold-rolled special shafting where a hard surface is needed.

4. *Complete Specification Form.*—Tractor manufacturers can make good use, it is believed, of a complete specification form for recording detailed technical data. (A Condensed Tractor Specification Form, already adopted by the Society, is intended mainly for general commercial requirements.)

The complete form will serve a purpose similar to that of the specification sheet included in the standard S. A. E. Engine Testing Forms. The recommended form is given below:

COMPLETE TRACTOR SPECFICAITIONS

1. Firm name .....
   Trade name .....Model .....
   Address .....

2. Horsepower rating:
   (a) Drawbar (old trade) .....S.A.E.....
   (b) Belt (old trade) .....S.A.E.....

3 Engine make .....
   Model .....

4. Number of Cylinders.....Cycle .....

5. Type of engine (*mark* ×)
   (Cyl. how cast)
   Vertical.....Valve in head.....Individual.....
   Horizontal .....L head ..... Pairs .....
   Opposed .....T head .....In block .....
   Removable head ..... Removable cylinder sleeve.....

6 Bore ..... in. Stroke, ...in.

7 Compression, ... lb. gage pressure.

8. Normal R. P. M. .....

9. Valves, make ..... Type .....
   *(a) Diameter, inlet valves, clear....in.; inlet valve, lift. in.
   (b) Diameter, exhaust valve, clear....in.; exhaust valve, lift....in.
   (c) Valve material. .....

10. Valve spring pressure at closed position.
   (a) Intake.....lb.
   (b) Exhaust.....lb.

11. Piston weight, with rings.....lb.
   Piston material .....

12. Piston clearance (for diameters).
   First land..... Third land.....
   Second land..... Skirt.....

13. Piston rings, number.....Width.....in.
   (a) Make or type .....
   *(b) Expansion pressure .....

14 Piston ring diameter .....Wall thickness .....

15. Oscillating bearing, length .....

16. Type of piston-pin bearing (*mark* × *for a, b, or c*):
   (a) Bearing in piston bosses .....
   (b) Bearing in connecting-rod end .....
   (c) Bearing in both .....
   (d) Method of holding piston pin .....

*Give pressure in ounces, as applied on the diameter 90-deg. distant from the diameter through the saw cut, which will just bring the ends of the ring together.

17. Governor: Make .....Type..... {Open..... / Enclosed ....

18. Connecting-rod length (c to c).....Brg. cap bolts: No. ....
   Dia.....in.
   Connecting-rod bearing: { Type.....Make..... / Diameter.....in.....Length....in. / Material.....
   Weight of connecting-rod complete with all bolts, nuts, bearings and piston-pin in place .....lb.

19. Crankshaft: Kind of steel .....Heat-treatment.....

20. Main crankshaft bearings, No. .....Type .....

Dimensions of Each Bearing.	Dia.	Length	Material
Front	.....in.	.....in.	.....
Second	.....in.	.....in.	.....
Middle	.....in.	.....in.	.....
Fourth	.....in.	.....in.	.....
Rear	.....in.	.....in.	.....

(Rear is flywheel end)

21. Flywheel: Diameter .....in.....Weight .....lb.

22. Method of attaching (*mark* ×):
   (a) Flange .....
   (b) Taper .....
   (c) Straight .....

23. Cams; Integral .....Separate .....

24. Camshaft bearings No. .....

	Dia.	Length	Material
Front	.....in.	.....in.	.....
Second	.....in.	.....in.	.....
Middle	.....in.	.....in.	.....
Fourth	.....in.	.....in.	.....
Rear	.....in.	.....in.	.....

25. Timing gears (*mark* × *for a or b*):
   (a) Spur .....
   (b) Helical .....
   (c) Crankshaft gear material .....
   (d) Camshaft gear material .....

26. Engine weight, complete with carbureter and ignition equipment ..... lb.

27. Lubrication system (*mark* × *except in g*):
   (a) Circulating .....(e) Splash.....
   (b) Non-circulating.....(f) Drilled crankshaft.....
   (c) Pressure feed .....(g) Mechanical lubricator..... make .....
   (d) Gravity feed .....(h) Ring type .....

28. Lubricating camshaft (*mark* ×):
   (a) Independent lead .....
   (b) Pressure .....
   (c) Splash .....

29. Lubrication, pistons (*mark* ×):
   (a) Splash .....
   (b) Pressure .....

30. Capacity, lubricating oil ..... gal.

31. Type of oil-pump (*mark* ×):
(a) Plunger .....
(b) Gear .....
(c) Individual .....

32. Location of oil-pump.....

33. Ignition system, make .....
Type: { Magneto, make...H.T...L.T...Direction of Rotation.
Impulse coupling .....
Battery ...Make ...Type ...Volts ....Amp. Hrs. ...
Make and break .....

34. Device for starting .....Make .....Volts .....

35. Spark-plug, make .....Size....Type { Extension ..... Standard.....

36. Carbureter, make .....

37. Carbureter, size .....Model .....

38. Exhaust—heat used for (*mark* ×):
Air .....
Fuel .....
Mixture in carbureter .....
Mixture in manifold .....

39. Hot-water jacket on (*mark* ×):
Carbureter .....
Manifold .....

40. Water injected with fuel .....Yes.....No.....

41. Fuel supply, type (*mark* ×):
(a) Gravity .....
(b) Pump .....
(c) Vacuum tank .....

42. Fuel tanks; Number .....
Capacity, gal.....gasoline.
Capacity, gal.....kerosene.

43. Air cleaner, make.....Size.....
(*mark* ×) (a) Dry ..... (b) Water .....

44. Radiator, make .....
Core: { Height .....in. Width .....in. Thickness .....in. Sectional .....in.

45. Capacity cooling system.....gal.; cooling fluid .....

46. Circulation:
Thermosyphon .....
Type .....
Pump: Delivery, gal. per minute at normal R.P.M.....

47. Air circulation:
Exhaust.....Make .....
Fan ..... Diameter .....in. Normal engine speed.....R.P.M. Type of drive .....

48. Belt pulley, make .....R.P.M.....
Material .....
Diameter .....Face.....

49. Type of belt-pulley drive (*mark* ×):
(a) Gear .....
(b) Direct .....
(c) Equipped with independent clutch .....
(d) Brake .....

50. Belt-pulley bearings, make .....

Type (*mark* ×):	Bore	O. D.	Width
Roller			
Ball			
Plain			

51. Transmission, make.....Type, open.....Enclosed.....

52. Clutch type: { Transmission .....Make.....Size.....in. Belt .....Make.....Size.....in.

53. Reductions (pairs of gears) engine to drive wheel, No.....

Reduction	Type of Gearing	Pitch	Face	Material	Finish	Heat Treatment
1st						
2nd						
3rd						
Final reduction						
Reverse						

SHAFT BEARINGS

	Type	Bore	Outside Diameter	Width	Material
1st shaft					
2nd shaft					
3rd shaft					
4th shaft					
Reverse					

54. Differential, open.....Enclosed.....Make.....

55. Differential gearing, type (mark ×):
(a) Bevel .....
(b) Spur .....
(c) Spiral .....Material .....Finish .....
(d) Interlocking .....

56. Differential main bearings, make .....

Type (*mark* ×):	Bore	O. D.	Width
Roller			
Ball			
Plain			

Thrust bearing, make .....Type .....

57. Does differential lock? Yes.....No. .....

58. Final drive type (*mark* ×):
Through axle..... { Gear.....
Through spokes..... { Gear.....
Through rim..... { Chain.....

59. Traction speed at normal engine R.P.M.:
(Also mark by (x) speed normally used for plowing.)

Speed	M.P.H.
1st	
2nd	
3rd	
4th	
Rev.	

60. Driving wheels, No. .....
Cast .....
Section of spoke.....
Built-up or cast in.....
Dia.....in. Face.....in.
Note—If tracklaying type, No. of tracks .....
Length.....in. Face.....in.

61. Drive-wheel axle, type and mounting (*mark* ×):
Stationary..... Spring .....
Live ..... Rigid .....
Dia. .....in. Material .....
Bearings, Make .....

Type (*mark* X):	Bore	O. D.	Width
Roller			
Ball			
Plain			

62. Non-drive wheels, No.....
Cast solid .....
Section of spokes.....
Built-up or cast in.....
Dia.....in. Face.....in.

63. Guide wheels, No. .....Dia.....in.....Face.....in.
Position.....Mounting..... { Spring..... Rigid.....
Spindle dia.....Material.....
Spindle bearings, make.....Type { Roller..... Ball..... Plain.....

64. Steering arrangement: { Knuckle type..... Swinging axle.....
Reversible.....Irreversible.....

65. Static weight on wheels (without water, fuel or oil):
Non-drive.....lb. Drive wheels.....lb.
.....lb. .....lb.

66. Frame, type: { Pressed.....Make..... Structural.....Material..... Cast .....

67. Side members, shape and size .....

68. Wheelbase, c to c of front and rear wheels.....ft.....in....
Gage .....ft. .....in.
(a) Total width over all.....ft.....in.
(b) Total width over rims....ft.....in.
Length over all .....

69. Turning radius (one-half diameter greatest track circle).....

70. Drawbar height, high .....Low.....
(S. A. E. Standard, 17 in.)

71. Drawbar swivelled? Yes.....No.....

72. Extension rims: Width.....in.

73. Lugs: Type.....Size.....

74. Clearance at lowest point (inches).....

75. Total weight of tractor (less fuel, oil, water and lugs).....lb.

76. Domestic shipping weight, including standard equipment and blocking.....lb.

77. Boxing for export, no. of boxes.....
For cubical contents and weight of each box:

	Contents, Cu.ft.	Weight, Lb.
1		
2		
3		
4		
5, etc.		

REPORT OF THE JUNE COUNCIL MEETING

THE June meeting of the Council was held at the Engineers Club, Dayton, on the 16th, the following being present: President C. F. Kettering, Vice-president David Beecroft, Second Vice-presidents Dent Parrett and H. R. Brate, Counselors B. B. Bachman, Chas. M. Manly, J. V. Whitbeck, Treasurer C. B. Whittelsey, Secretary Coker F. Clarkson, and Past-president Howard E. Coffin.

It was voted to make the following transfers from Associate to Member grade: Harold G. Bowker, David F. Chambers, Frank W. Edwards, and Wm. H. Mooney.

Applicants to the number of 50 were elected to membership in the Society, these being assigned to grades as follows: 19 Members, 20 Associates, 9 Junior Members, 1 Affiliate Member, and 1 Affiliate Member Representative.

The reports of the Aeronautic, Ball and Roller Bearings, Data Sheet, Electric Equipment, Iron and Steel, Engine, Tire and Rim, and Tractor Divisions of the Standards Committee, which had been accepted by the Committee, were approved by the Council for submission to the Society meeting on the 17th of June.

It was decided to create Spline Fittings and Non-Ferrous Metals Divisions of the Committee; the personnel of these divisions will be announced later.

The following subjects were approved for assignment to the Farm and Stationary Gas Engine Division:

Present standards of the National Gas Engine Association relating to cap screws, screw threads, lock washers.

Piston rings, pins, engine bushings, crankshaft diameters, extensions for pulleys.

Valves, valve collars, connecting-rods, bolts.

Pipe flanges (oval and round), flanges for cast-iron carbureters.

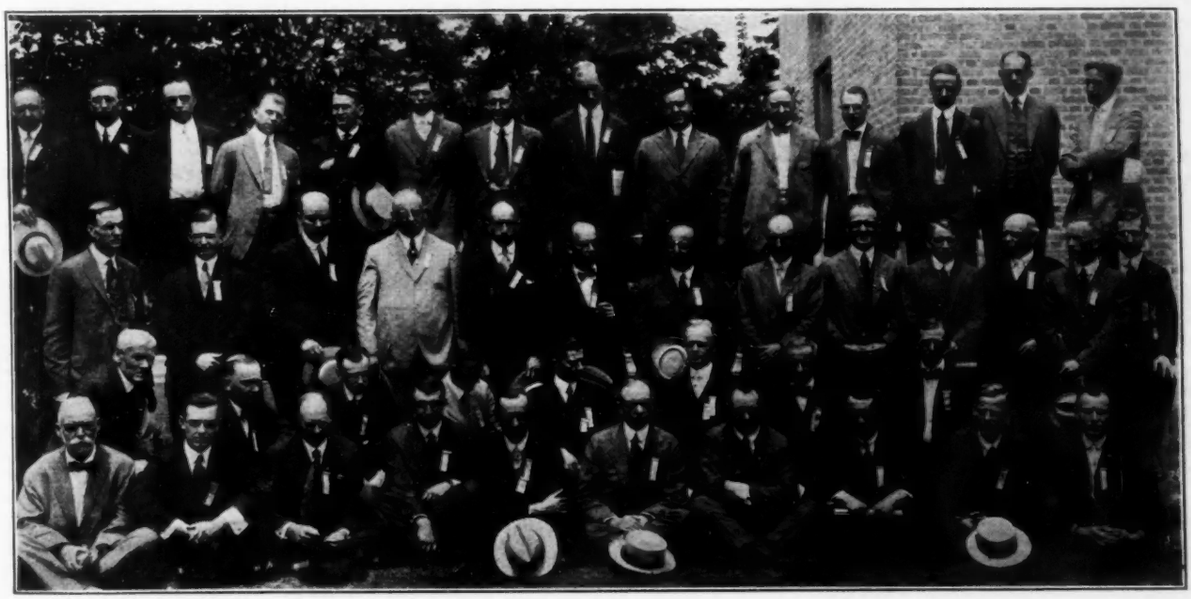
Engine mounting dimensions for portable truck installations.

Cylinder lubricators, grease cups.

Applicability of S. A. E. recommended practices and standards to farm engine work.

The subject of rim contours and thicknesses was approved for assignment to the Tire and Rim Division.

The next meeting of the Council will be held in October, unless it is deemed advisable to meet at an earlier date.



MEMBERS AND GUESTS PRESENT AT MEETING OF STANDARDS COMMITTEE, DAYTON, JUNE SIXTEENTH

Honor Roll of Society Members

THE following members have recently entered the services of the government in civilian or military capacities. This list, together with the "Service Directory of Members" following, is intended to contain the names of all members connected with the government, either in the military service or in civilian capacities. The names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct. It is therefore requested, in case of any error, that the member concerned immediately inform the New York office of the Society, so that a proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York office.

MILITARY HONOR ROLL

Barnes, Nevin C., cadet, U. S. School of Military Aeronautics, Princeton, N. J.

De la Garde, Louis A. C., lieutenant, Motor Transport Army Service Corps, Chiswick, London, England, assigned as first-class engineer and workshops officer.

Frehse, A. W., captain, Engineering Section, Motor Transport Service, Quartermaster Corps, N. A., Washington.

Howland, Wm. I., Jr., lieutenant, Bureau of Ordnance, Navy Department, U. S. N. R. F., Washington.

Mayer, James L., lieutenant, 109th Engineers, Camp Cody, New Mexico.

Morse, E. R., first lieutenant, Headquarters 6th Mobile Ordnance Repair Shop, Camp Wadsworth, S. C.

Proctor, C. D., Corporal, Ordnance Department, U. S. A., Ordnance Depot, Chicago.

Pullen, Daniel D., lieutenant colonel, General Headquarters, A. E. F., A. P. O. 706, France.

Thompson, W. H. F., Barracks 300, League Island Navy Yard, Philadelphia, assigned as machinist's mate.

Tyler, P. O., captain, Ordnance R. C., U. S. A., Raritan Arsenal, Nixon, N. J.

Weiss, Erwin A., sergeant, Engineering Bureau, Motor Section, Ordnance Department, U. S. A., France, assigned as ordnance sergeant.

CIVILIAN HONOR ROLL

Bourne, Stephen N., secretary, Emergency Fleet Corporation, Philadelphia.

Brown, William G., Aircraft Division, Research Department, Bureau of Construction and Repair, Navy Department, Washington.

Ducorron, C. A. F., Signal Corps, U. S. A., care Nordyke & Marmon Co., Indianapolis, assigned as senior inspector, Signal Service at Large.

King, Chas. P., Aviation Section, Signal Corps, U. S. A., New York, assigned as aeronautical mechanical engineer.

Loomis, Allen, Bureau of Aircraft Production, McCook Field, Dayton, assigned to airplane engineering department.

McMaster, Marcenus D., Aviation Section, U. S. N. R. F., Washington, assigned as warrant officer and machinist.

Roberts, Samuel B., Signal Corps, U. S. A., care Sturtevant Aeroplane Co., Boston, assigned as inspector of airplanes.

Roberts, D. S., Signal Corps, U. S. A., care Sturtevant Aeroplane Co., Boston, assigned as inspector of airplanes.

Reid, James, Boston Navy Yard, Bldg. 105, Shipsmith's Office, Boston.

Suttill, Albert G., Merchant Shipbuilding Corp., Bristol, Pa., assigned as inspector of machinery, Boston District. (mail) General Delivery, Hyde Park, Mass.

Wright, E. H., Bureau of Aircraft, McCook Field, Dayton, assigned to factory manager's office, experimental department.

Service Directory of Members

Military Service

ALDEN, HERBERT W., lieutenant-colonel, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

ALDRIN, EDWIN E., lieutenant, Coast Artillery Corps, U. S. A., *Ft. McKinley, Maine.*

ALTER, ARTHUR S., chief machinist's mate, U. S. N. R. F., *Washington.*

AMON, CARL H., first lieutenant, Aviation Section, Signal R. C., 1st Motor Mechanics' Regiment, A. E. F., *France.*

ANDERSON, OSCAR G., private, Co. A, 1st Prov. Ordnance Depot Battalion, U. S. A., (mail) P. O. No. 713, A. E. F.

ANDERSON, E. S., lieutenant, Aviation Section, Signal Corps, U. S. A., Rockwell Field, *San Diego, Cal.*

ANDERSON, WILLIAM C., lieutenant, Engineer R. C., *Brooklyn, N. Y.*

ARNOLD, BION J., lieutenant colonel, Aviation Section, Signal R. C., *Washington.*

BAKER, FRANCIS H., chief machinist's mate, U. S. N. R. F., U. S. Naval Gas Engine School, Columbia University, *New York.*

BARE, ERWIN L., first lieutenant, Military Truck Production Section, Quartermaster Corps, U. S. N. A., 205 Union Station, *Washington.*

BARKER, C., pilot cadet, Royal Flying Corps, *Canada.*

BARKER, C. NORMAN, pilot cadet, Royal Flying Corps, *Camp Borden, Can.*

BARNABY, R. S., ensign, U. S. N. R. F., *Buffalo,* assigned to inspection duty.

BARTON, W. E., first lieutenant, Quartermaster R. C., *Washington.*

BATES, WM. O., JR., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

BEDFORD, E. A., U. S. A., A. E. F., *France.*

BENJAMIN, DAVID, Co. A, Training Detachment, *Valparaiso, Ind.*

BEVIN, SYDNEY B., captain, Engineering Bureau, Motor Equipment Section, Ordnance Department, U. S. R., *Washington.*

BIBB, JOHN T., JR., second lieutenant, reserve military aviator, Aviation Section, Signal R. C., *Washington.*

BIBB, JOHN T., JR., lieutenant, Aviation Section, S. R. C., Love Field, *Dallas, Texas.*

BIGELOW, A. C., second lieutenant, Motor Transport Section, Quartermaster Corps, U. S. A., 205 Union Station, *Washington.*

BILLINGS, C. M., first lieutenant, Ordnance Department, U. S. A., *Rock Island, Ill.*

BLAIR, C. A., corporal, 472d Aero Squadron, A. E. F., *France.*

BLANK, M. H., first lieutenant, Motor Equipment Division, Ordnance R. C., Grant Motor Car Co., *Cleveland.*

BLEAKLEY, P. A., sergeant, Ordnance Department, U. S. N. A., Camp Herring, *Peoria, Ill.*

BRINTON, BRADFORD, major, Quartermaster Corps, U. S. A., *Washington.*

BLOOD, HOWARD E., captain, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned as business executive, Airplane Engineering Department.

BOGGS, GEO. A., lieutenant, Quartermaster Corps, U. S. A.; (mail) Farmers Loan & Trust Co., *Paris, France.*

SIDE GUIDE & G

SERVICE DIRECTORY OF MEMBERS

BOWEN, C. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

BRANDMEIER, F. M., Signal Corps, U. S. A., Motor Transport School, Wilbur Wright Field, *Fairfield, Ohio.*

BRISCOE, FRANK, captain, Signal Corps, U. S. A., *France.*

BRITTEN, DANIEL L., captain, Ordnance R. C., *Washington*, assigned to Gun Division, Ordnance Section.

BRITTEN, WM. M., major, engineer of motor transportation, Quartermaster R. C., *Washington.*

BRODIE, JAMES S., Engineer Corps, U. S. N. A., *Washington.*

BROWN, HAROLD HASKELL, first lieutenant, Coast Artillery Corps, U. S. N. A., *Fort Totten, N. Y.*

BROWNE, ARTHUR B., captain, Sanitary Corps, U. S. N. A., (mail) General Motors Co., *Detroit.*

CALLAN, JOHN LANSING, lieutenant, Reserve Flying Corps, U. S. N., U. S. S. Seattle, (mail) Postmaster, *New York.*

CAMPBELL, ARCHIBALD F., Aviation Section, Signal R. C., *Washington.*

CAMPBELL, LINDSEY F., 4th Battery, 2d P. T. R., *Fort Sheridan, Ill.*

CHASE, A. M., major, Ordnance Department, U. S. A., *Washington.*

CLARK, EDWARD L., first lieutenant, Signal R. C., McCook Field, *Dayton, Ohio.*

CLARK, ELMER J., captain, Signal R. C., *Buffalo, N. Y.*

CLARK, VIRGINIUS E., lieutenant colonel, Signal Corps, U. S. A., *Washington.*

CLARKE, A. FIELDER, Ground School, Aviation Section, U. S. N., *Washington.*

CLEAVER, CHARLES F., captain, A. S. C., British War Department, London, Eng., assigned as inspector of mechanical transport, (mail) Peerless Motor Car Co., *Cleveland.*

COCKRILL, EMMET, first lieutenant, Ordnance R. C., Ford Motor Co., *Highland Park, Mich.*, assigned as production officer and mechanical engineer.

COE, EDW. M., first lieutenant, Quartermaster Corps, U. S. A., *Washington*, (mail) Mechanical Repair Shops No. 302, A. E. F., *France.*

COFFMAN, DON M., first lieutenant, Aviation Section, Signal R. C., Commercial Bldg., *Dayton, Ohio.*

COLLINS, KENNETH G., first lieutenant, Signal R. C., A. E. F., *Italy*, (mail) 8th Aviation Instruction Center.

COMSTOCK, HERBERT F., cadet, Aviation Section, Signal Corps, A. E. F., (mail) 16th Foreign Detachment, A. P. O. 725, via *New York.*

DAHLQUIST, CHAS. S., major, Quartermaster Department, U. S. N. A., *Washington*, assigned to Motors Division as supervisor of inspection on standardized military trucks.

DAYTON, WILLIAM E., private, 306th Regiment, Field Artillery, U. S. N. A., *Washington.*

DEEDS, EDWARD A., colonel, Equipment Division, Signal Corps, U. S. A., State, War and Navy Bldg., *Washington.*

DENISON, ARTHUR H., cadet, School of Military Aeronautics, Massachusetts Institute of Technology, *Cambridge, Mass.*

DE LORENZI, ERNEST A., officer, Mechanical Transport, War Department, *London, Eng.*

DE WITT, GEORGE W., ensign, U. S. N., *France*, (mail) U. S. S. Utowana, Postmaster, *New York.*

DIAMOND, JAMES E., captain, Ordnance R. C., assigned to Motor Instruction School, *Kenosha, Wis.*

DICKEY, HERBERT L., captain, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

DIMOND, G. A., first lieutenant, Motor Section, Ordnance R. C., Ft. Herring, *Peoria, Ill.*

DONALDSON, FRANK A., captain, Carriage Division, Ordnance R. C., Sixth and B Sts., *Washington.*

DOST, CHARLES O., first lieutenant, Aviation Section, Signal Corps, U. S. A., Ellington Field, *Houston, Texas*, assigned to engineering department.

DU BOSE, GEO. W. P., major, American Ordnance Base Depot, A. E. F., *France.*

DUNCAN, A. C., first lieutenant, Balloon Co. No. 7, Signal Corps, Aviation Section, Signal R. C., (mail) A. E. F., *France.*

DUNTLEY, LLOYD B., first lieutenant, Ordnance R. C., *Washington*, assigned to Engineering Motor Equipment Section.

EARLE, LAWRENCE H., captain, Ordnance R. C., assigned as inspector of ordnance, Holt Mfg. Co., *Peoria, Ill.*

EELLS, PAUL W., lieutenant, 330th Field Artillery, Artillery R. C., Camp Custer, *Battle Creek, Mich.*

EGGEN, O. E., 337th Field Artillery, Ordnance Corps, U. S. A., Camp Dodge, *Iowa.*

EHLERS, PAUL, Battery E, 304th Field Artillery, U. S. A., A. E. F., *France.*

ENGESSER, BENJ. M., School of Military Aeronautics, Massachusetts Institute of Technology, *Cambridge, Mass.*

ENGLISH, G. H., JR., first lieutenant, Ordnance R. C., *Washington.*

EVANS, GORDON M., captain, Engineering Bureau, Motor Equipment Section, Ordnance Department, U. S. R., *Washington.*

FARRELL, MATTHEW, captain, Quartermaster R. C., *Washington.*

FINKENSTAEDT, EDWARD R., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

FISHLEIGH, W. T., major, Sanitary Corps, U. S. N. A., *Washington*, assigned as automobile engineer.

FITZGERALD, GERALD, second lieutenant, Motor Truck Co. 348, Camp McArthur, *Texas.*

FLANIGAN, E. B., Officers' Reserve Training Camp, *Plattsburg, N. Y.*

FORRER, J. D., captain, Engineer R. C., *Washington.*

FOSS, CLARENCE M., captain, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section.

FOSTER, WILLIAM J., second lieutenant, Signal R. C., U. S. A., *Washington*, assigned to Engine Design Section, Airplane Engineering Department, Aviation Section.

FOX, RUDOLPH H., first lieutenant, Ordnance R. C., *Washington.*

FRANKLIN, G. KING, captain, Motor Section, Ordnance R. C., *Washington.*

FREDRICKSEN, ARTHUR, first-class machinist's mate, Aviation Section, U. S. Navy, Camp Perry, *Great Lakes, Ill.*

FREVERT, CARL B., first lieutenant, Ordnance R. C., A. E. F., *France.*

FRIEDGEN, A. E., first lieutenant, Engineering Section, Motor Transport Service, Quartermaster Corps, *Washington.*

FULTON, RICHARD WALLACE, 5th Cadet Squadron, Aviation Section, Signal Corps, U. S. A., *Houston, Texas.*

FURLOW, JAMES W., lieutenant colonel, Quartermaster Corps, U. S. A., *Washington*, assigned to Office of Quartermaster General.

GAEBELEIN, ARNO W., lieutenant, Ordnance R. C., *Washington*, assigned to Carriage Division.

GARDNER, LESTER D., captain, 117th Aero Squadron, Signal Corps, U. S. A., *Washington.*

GETSCHMAN, G. F., second lieutenant, Ordnance R. C., *Washington*, (mail) Office of Inspector of Ordnance, Maxwell Motor Co., Chalmers Plant, *Detroit.*

GEY, WILLIAM, 377th Truck Train, U. S. N. A., Camp Merritt, *Tenafly, N. J.*

GFRORER, A. H., first lieutenant, Ordnance R. C., assigned as production officer, Maxwell Motor Co., Chalmers Motor Car Co., *Detroit.*

GIBBS, S. E., U. S. School of Military Aeronautics, University of Illinois.

GILLIS, HARRY A., major, Ordnance R. C., *Washington.*

GLOVER, F. S., major, Ordnance R. C., *Washington.*

GORRELL, EDGAR S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., *Washington*, (mail) Air Service, A. E. F., *France.*

GRAHAM, LOUIS, captain, 309th Engineers, Engineers R. C., *Camp Zachary Taylor, Ky.*

GRAY, B. D., major, chief of production engineering department, Equipment Division, Aviation Section, Signal Corps, U. S. A., *Washington.*

GRAY, SAMUEL W., first lieutenant, Aviation Section, Signal R. C., U. S. A., (mail) 4th Co., 2d Motor Mechanics Regiment, Air Service A. E. F., *France.*

GREEN, GEO. A., major, Tank Section, British E. F., *France.*

GUERNSEY, CHARLES, captain, Engineering Section, Motor Transport Service, Quartermaster Corps, U. S. N. A., *Washington.*

GUTHRIE, JAMES, major, Ordnance R. C., *Washington*, assigned to Carriage Division, Engineering Bureau.

HAESKE, F. C., lieutenant, U. S. A., Camp Sherman, *Chillicothe, Ohio.*

HALL, C. M., major, Aviation Section, Signal Corps, U. S. A., *Dayton, Ohio.*

HALL, ELBERT J., major, Engine Design Section, Engineering Division, Signal Corps, U. S. A., *Washington.*

HALL, RICHARD H., JR., first lieutenant, Quartermaster Corps, U. S. N. A., *Washington.*

HARMS, HENRY W., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., (mail) Base Section No. 3, *London, England.*

HARTMAN, A. A., private, U. S. N. A., Camp Devens, *Ayer, Mass.*

HAWKE, CLARENCE E., Aviation Section, Signal Corps, U. S. A., *Washington.*

HECKEL, C. E., second lieutenant, Motor Transport Division, Quartermaster Corps, *Washington.*

HECOX, F. C., captain, Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Bureau, Motor Division, in charge of standardization of military motorcycles.

HEGEMAN, HARRY A., major, Quartermaster Corps, U. S. A., *Washington*, assigned to office of Officer in Charge of Transportation.

HENDERSON, S. W., first lieutenant, Ordnance R. C., *Washington.*

HICKS, HARLIE H., captain, Aviation Section, Signal R. C., *Washington.*

HOBBS, J. W., first lieutenant, Ordnance R. C., U. S. A., commanding officer, Fourth Heavy Mobile Ordnance Repair Shop, *Camp Hancock, Ga.*

HOFFMAN, ROSCOE C., captain, Carriage Division, Motor Equipment Section, Ordnance R. C., *Washington.*

HORINE, M. C., second lieutenant, Aviation Section, Signal R. C., *Washington.*

HORNER, LEONARD S., major, Equipment Division, Signal Corps, U. S. A., *Washington.*

HOWARD, WALTER S., first lieutenant, Military Truck Production Section, office of Quartermaster General, *Washington.*

HOUSTON, HAROLD S., 3d Officers' Training Camp, *Fort Monroe, Va.*

HOYT, F. R., lieutenant, Aviation Section, Signal R. C., A. E. F., *France.*

HUBBELL, LINDLEY D., lieutenant colonel, U. S. N. A., Ordnance Department, *Springfield, Mass.*, assigned as Officer in Charge, Hill Shops, Springfield Armory.

HULL, M. LAIR, private, Ordnance Department, U. S. A., *Washington*, assigned to Trench Warfare Unit, Requirement Section, Control Bureau.

JACO, E. L., captain, Engineer R. C., U. S. A., *Washington*, assigned to General Engineering Depots.

JEFFREY, MAX L., first lieutenant, Military Truck Production Section, Office of Quartermaster General, *Washington.*

JENKS, WESTON M., U. S. N. R. F., Massachusetts Institute of Technology, *Cambridge, Mass.*, assigned as instructor in naval aviation.

JENNINGS, J. J., first lieutenant, Engineer R. C., Office of Chief Engineer, A. E. F., P. O. 717.

JONES, R. E., lieutenant, U. S. N. R. F., Washington, (mail) U. S. S. New York, Postmaster, *New York City.*

SIDE GUIDE & G

JOY, HENRY B., lieutenant colonel, 4th Motor Mechanics Regiment, Signal Corps, U. S. A., *Camp Hancock, Ga.*

JUNK, FRED H., second lieutenant, Aviation Section, Signal R. C., U. S. A., (mail) Signal Corps Aviation School, Carlstrom Field, *Arcadia, Florida.*

KALB, LEWIS P., major, Quartermaster Corps, U. S. N. A., *Washington.*

KENDRICK, JOHN F., Signal Corps, A. E. F., *France,* assigned to Research Inspection Division.

KENNEDY, H. H., lieutenant, Ordnance Department, U. S. A., *Washington,* assigned as inspector of ordnance.

KINKEAD, R. S., sergeant, Third Reserve Officers' Training Corps, Field Artillery, *Washington.*

KLEMIN, ALEXANDER, sergeant, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio;* assigned to research, Airplane Engineering Department, Aviation Section.

KLINE, H. J., first lieutenant, Ordnance R. C., *Washington,* assigned to Anti-Aircraft Section, Carriage Division.

KLOCKAU, W. F., private, Co. N, 4th Battalion, 163rd Depot Brigade, *Camp Dodge, Iowa.*

KOHR, ROBERT F., second lieutenant, Engineers R. C., *Washington.*

KOTTNAUER, EDWIN H., first lieutenant, inspector of ordnance, Ordnance R. C., U. S. A., (mail) Paige-Detroit Motor Car Co., *Detroit.*

LANDON, CHARLES H., second lieutenant, Aviation Section, Signal R. C., Camp Dick, *Dallas, Tex.*

LANE, ABBOTT A., first lieutenant, Aviation Section, Signal R. C., *Detroit, Mich.*

LANZA, MANFRED, major, Quartermaster Corps, U. S. A., 303rd Motor Supply Train, Camp Dix, *Wrightstown, N. J.*

LARSEN, LESTER REGINALD, second lieutenant, 107th Engineer Train, U. S. A., A. E. F., *France.*

LAVERY, GEO. L., JR., first lieutenant, Ordnance R. C., *Washington.*

LAY, ARTHUR J., captain, Aviation Section, Signal R. C., *Washington.*

LE FEVRE, WM. G., lieutenant, Train, 77th Division, U. S. A., *Camp Upton, New York.*

LEOPOLD, JOSEPH, second lieutenant, Aviation Section, Signal R. C., Massachusetts Institute of Technology, *Cambridge, Mass.*

LEVY, ALFRED K., 3rd Ordnance Corps, assigned to Motor Equipment Section, U. S. N. A., *Washington.*

LEWIS, CHARLES B., captain, Ordnance R. C., Camp Lewis, *American Lake, Wash*

LEWIS, HARRY R., JR., captain, Ordnance R. C., Springfield Armory, *Springfield, Mass.*

LIBBEY, E. B., captain, 102nd Ammunition Train, 27th Division, U. S. A., *Spartanburg, S. C.*

LIPSNER, B. B., captain, Record Section, Aviation Section, Signal R. C., *Washington.*

LOEB, S. ARTHUR, lieutenant, Signal R. C., U. S. A., (mail) General Motors Corp., Buick Division, *Flint, Mich.*

LUDOLPH, F. E., Aviation Section, Signal Corps, U. S. A., Kelly Field No. 1, *S. San Antonio, Tex.*

MACDONALD, K. B., lieutenant commander, U. S. N. R. F., Naval Aircraft Factory, League Island Navy Yard, *Philadelphia.*

MCCORMICK, BRADLEY T., captain, Ordnance Department, U. S. A., *New York.*

MCGILL, GEO. E., Equipment Division, Aviation Section, Signal Corps, U. S. A., Packard Motor Car Co., *Detroit.*

MCINTYRE, H. C., captain, Ordnance R. C., *Washington.*

MCMURTRY, ALDEN L., captain, Quartermaster Corps, U. S. N. A., *Washington.*

MACKIE, MITCHELL, major, Quartermaster Corps, U. S. A., A. E. F., *France,* assigned to Motor Truck Transport Section.

MACCOULL, NEIL, JR., U. S. N. R., *Washington.*

MARMON, HOWARD, major, Airplane Engineering Division, Signal R. C., McCook Field, *Dayton, Ohio.*

MARSHALL, W. C., captain, Ordnance R. C., *Washington.*

MARTIN, KINGSLEY G., captain, Quartermaster R. C., *Camp Dodge, Iowa.*

MASON, GEO. R., lieutenant, A. E. F., *France.*

MATTHEWS, MEREDITH, sergeant of ordnance, 7th Mobile Ordnance Repair Shop, 7th Division, U. S. A., (mail) Camp McArthur, *Waco, Texas.*

MAY, HENRY, JR., first lieutenant, Quartermaster C., N. A., *Washington,* assigned as inspector of Type B engines.

MEDER, CHARLES, 2nd Regiment, Co. 10, Section 1, Aviation Section, U. S. Naval Training Station, *Charleston, S. C.*

MERGI, WILLIAM, Co. B, First Battalion, 153d Depot Brigade, Camp Dix, *Wrightstown, N. J.*

METCALF, GEORGE R., JR., captain, Ordnance Department, U. S. N. A., *Washington.*

MICHEL, C. A., The Naval Auxiliary, Reserve Officers' Training School, Steamer J. H. Sheadle, Detroit River Station.

MIDDLETON, RAY T., first lieutenant, Air Service, A. E. F., *Paris, France.*

MILLER, B. F., major, Quartermaster Corps, U. S. A., *Washington.*

MILLER, C. A., first lieutenant, head checker, Quartermaster Corps, U. S. N. A., *Washington.*

MILLER, DONALD G., first lieutenant, Ordnance R. C., U. S. A., (mail) Nash Motors Co., *Kenosha, Wis.*

MITCHELL, C. B., lieutenant, 4th Motor Mechanics' Regiment, *Camp Hancock, Ga.*

MOFFAT, ALEX. W., ensign, commanding U. S. S. "Tamarack" (S. P. 561), Naval Defense Reserve, Postmaster, Foreign Station, *New York.*

MOFFETT, PAUL R., captain, Aviation Section, Signal Corps, *Washington.*

MONCRIEFF, V. I., captain, Aviation Section, Signal R. C., *Washington.*

MOORE, HAROLD T., sergeant, Quartermaster Mobile Repair Shop No. 302, Co. 2, American Expeditionary Forces, via *New York.*

MORGAN, M. B., major, Engineering Division, Motor Equipment Section, Ordnance Department, *Washington.*

MORRISS, PERCY G. B., Naval Aviation Corps, U. S. Navy, *Washington,* (mail) Aviation Headquarters, Great Lakes Naval Station, *Great Lakes, Ill.*

MURPHY, JOSEPH G., Sanitary Corps, U. S. N. A., *Washington.*

MYERS, J. L., first lieutenant, Motor Equipment Section, Ordnance R. C., U. S. A., (mail) Allison Experimental Co., *Indianapolis.*

NAHIKIAN, S. M., lieutenant, Aviation School, Massachusetts Institute of Technology, *Cambridge, Mass.*

NICHOL, ALFRED H., Biplane Engineering Department, Signal Corps, U. S. A., *Dayton.*

NORRIS, G. L., captain, Signal R. C., U. S. A., *Pittsburgh, Pa.*

O'BRIEN, WM. B., JR., cadet, School of Military Aeronautics, Barracks No. 1, *Champaign, Ill.*

OGREN, CARL F., chief machinist's mate, Ordnance Inspection Department, U. S. N. R. F., *Washington.*

OLDFIELD, LEE W., captain, Signal R. C., *Washington,* assigned as aeronautical engineer.

OLIPHANT, LAURENCE, ensign, U. S. N., *Washington.*

OMMUNDSON, H. P., chief quartermaster, Aviation, U. S. Naval Air Station, *Miami, Fla.*

ONG, D. G., first lieutenant, Aviation Section, Signal Reserve Corps, U. S. A., *Dayton, Ohio.*

ORTON, EDWARD, JR., major, Quartermaster R. C., *Washington,* assigned to Motor Transport Branch, Engineering Section.

OSBORNE, ARTHUR D., second lieutenant, Ordnance R. C., U. S. A., *Washington.*

OSWALT, W. L., first lieutenant, Ordnance R. C., 304th Mobile Ordnance Repair Shop, *Camp Meade, Md.*

OTTO, HENRY S., lieutenant, Intelligence Section, A. E. F., *France.*

PAGE, VICTOR W., first lieutenant, Aviation Section, Signal R. C., *Mineola, N. Y.*

PAINE, C. L., captain, Ordnance R. C., U. S. A., Headquarters 7th Mobile Ordnance Repair Shop, Camp McArthur, *Waco, Texas.*

PARKER, RICHARD E., captain, Quartermaster R. C., *Washington,* assigned to Southern Department.

PARRAMORE, T. H., Motor Transport Service, Quartermaster Corps, U. S. A., *Washington.*

PEARMAIN, W. J., captain, Ordnance R. C., A. E. F., *France.*

PECHNICK, FRANK J., 31st Balloon Co., U. S. A., Post Field, *Ft. Sill, Okla.*

PETERSON, F. SOMERS, ensign, Naval Air Station, *San Diego, Cal.*

PETTIS, JOHN G., chief machinist's mate, Aviation Section, U. S. N., *Washington.*

PFEIFFER, BEN. S., first lieutenant, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.,* assigned to Motor Section.

PICKARD, LYNN W., chief machinist's mate, U. S. Naval Air Service, A. E. F., *France.*

PIERCE, HUGH M., captain, Signal R. C., Call Field, *Wichita Falls, Texas,* assigned as engineer officer, Aviation Section.

POST, EDWIN M., JR., lieutenant, U. S. Air Service, A. E. F., *France.*

POTTER, AUSTIN E., lieutenant, U. S. N. R. F.; U. S. Naval Aviation Forces, *France.*

POWELL, W. B., captain, assigned as officer in charge of mechanical transport, Imperial Ministry of Munitions, *Quebec, Can.,* (mail) P. O. Box 194.

PRATT, JESSE T., first lieutenant, Aviation Section, Signal Corps, U. S. A., *Washington.*

PULLEN, DANIEL D., lieutenant colonel, Tank Corps, Corps of Engineers, Headquarters A. E. F., *France.*

PURCELL, BERNARD A., captain, Quartermaster R. C., 307th Supply Train, *Camp Gordon, Ga.,* assigned as Commanding Officer.

RANNEY, A. ELLIOT, major, Air Division, Signal Corps, U. S. A., *Washington.*

RAWLEY, JOS., captain, Co. A, 310 Engineers, U. S. A., Camp Custer, *Battle Creek, Mich.*

RICHARDSON, F. E., private, Engineer R. C., U. S. A., *Washington.*

RIDDLE, E. C., cadet, Aviation Section, Gerstner Field, *Lake Charles, La.*

RIFKIN, G., sergeant, inspector, Military Truck Production Division, Quartermaster Corps, U. S. N. A., (mail) Covert Gear Works, *Lockport, N. Y.*

RITTER, E. R., first lieutenant, Ordnance R. C., U. S. A., *Washington,* assigned to Production Division, Carriage Section.

ROBINSON, H. A., ensign, N. R., U. S. N., *Keyport, N. J.*

ROSE, CHARLES B., major, chief of planes and engine inspection, Inspection Department, Signal Corps, U. S. A., *Washington.*

ROMEYN, RADCLIFFE, Inspection Division, Ordnance Department, *Washington.*

ROSENTHAL, WM. C., sergeant, Engineer O. T. C., *Camp Lee, Va.*

ROUNDS, EDWARD W., U. S. N. R., U. S. Naval Aviation Detachment, *Cambridge, Mass.*

RUMNEY, MASON P., captain, Production Division, Ordnance R. C., *Washington.*

RUSSELL, EUGENE F., major, Ordnance Department, U. S. A., *Washington.*

SANDT, A. R., sergeant, Ordnance Department, U. S. A., *Washington,* assigned to Motor Equipment Section, Engineering Bureau.

SCHOENFUSS, F. H., captain, Gun Division, Production Section, Ordnance R. C., *Washington.*

SCHOEPF, T. N., captain, Engineer R. C., *Washington.*

SCHUPP, ARTHUR A., second lieutenant, Aviation Section, Engineering Department, New York Equipment District, Signal Corps, U. S. A., *Washington.*

SCOTT, ALLISON F. H., captain, Signal Corps, U. S. A., Langley Field, *Hampton, Va.*, assigned to Aviation Section.

SELFRIDGE, S. W., first lieutenant, Ordnance R. C., *Washington.*

SEWALL, E. B., U. S. N. R. F., *Washington.*

SHAFER, M. S., second lieutenant, Signal R. C., McCook Field, *Dayton, Ohio*, assigned to Airplane Eng. Div.

SKINNER, HARLAN C., private, Ordnance Department, U. S. A., Edgewood Arsenal, *Edgewood, Md.*

SLADE, ARTHUR J., captain, Aviation Section, Signal R. C., *Washington.*

SLOANE, JOHN E., first lieutenant, aeronautical engineer, Aviation Section, Signal Corps, U. S. A., *Washington.*

SMITH, EDSON H., ensign, U. S. N. R., (mail) American & British Mfg. Co., *Bridgeport, Conn.*, assigned as assistant naval inspector of Ordnance.

SMITH, FRANK E., major, Signal Corps, U. S. A., *Washington.*

SMITH, G. W., JR., lieutenant, U. S. N. R., Naval Aircraft Factory, U. S. Navy Yard, *Philadelphia.*

SMITH, MARK A., first lieutenant, Marine Corps, U. S. N., *Washington.*

SMITH, WESTCOTT T., second lieutenant, Engineering Department, Aviation Section, Signal R. C., U. S. A., Chaunte Field, *Rantoul, Ill.*

SPENCE, HANS P., first lieutenant, Quartermaster Corps, U. S. A., *Camp Custer, Mich.*

SPERRY, LAWRENCE B., ensign, U. S. N. R. F., *Massapequa, N. Y.*

SPRAGUE, G. A., Co. D, 310th Engineers, Camp Custer, *Battle Creek, Mich.*

STAHL, R., lieutenant, U. S. Navy Seaplane Division, U. S. N. R., *Washington.*

STALB, A. ROLSTAN, ensign, U. S. N. R. F., (mail) Office of Operations, Aviation, Navy Annex, *Washington.*

STEINAU, J. M., sergeant, Sanitary Corps, U. S. N. A., *Washington.*

STEVENS, C. C., Motor Equipment Section, Ordnance Department, U. S. A., *Washington*, assigned as draftsman.

STRAHLMAN, OTTO E., first lieutenant, Aviation Section, Signal R. C., (mail) Mechanics Training School, Overland Bldg., *St. Paul, Minn.*

STRAUSS, M. FRANK, first lieutenant, 307th Mobile Ordnance Repair Shop, 82nd Division, U. S. A., *Camp Gordon, Ga.*

STREETER, ROBT. L., major, Ordnance Department, U. S. A., *Rock Island Arsenal, Ill.*, in charge of truck and tractor experimental work.

STREICHER, GEORGE A., lieutenant, 3rd Engineers' Training Regiment, *Camp Humphrey, Va.*

SWEET, GEO. P., first lieutenant, Signal Corps, U. S. A., *Washington*, assigned to Aviation Section.

SWEET, GEO. W., captain, Ordnance Department, U. S. A., *Washington*, assigned as inspector of ordnance, Studebaker Corp., *South Bend, Ind.*

SWINTON, D. R., first lieutenant, Quartermaster Corps, U. S. N. A., Mobile Repair Shop 202, A. P. O. 708, A. E. F., *via New York.*

TAYLOR, PAUL B., sergeant, Medical Corps, U. S. A., *Pontiac, Mich.*

TAYLOR, S. G., JR., first lieutenant, Ordnance R. C., *Washington*, assigned to Ordnance Department.

TEETOR, D. C., captain, Ordnance R. C., *Kenosha, Wis.*, assigned to Motor Section.

THOMPSON, H. E., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

THOMPSON, JOHN A., Ordnance Department, U. S. A., assigned to Engineering Bureau, Motor Equipment Section, Ford Bldg., *Washington.*

TITSCH, WALTER H., captain, Quartermaster Corps, U. S. N. A., A. E. F., *France.*

TOLMAN, EDGAR BRONSON, JR., first lieutenant, 311th Engineers, U. S. A., Camp Grant, *Rockford, Ill.*

TURNER, HARRY C., captain, Engineer R. C., A. E. F., *France.*

TWACHTMAN, QUENTIN, first lieutenant, Engine Design Section, Signal R. C., *Washington.*

TYLER, O. P., captain, Ordnance R. C., Headquarters 22nd Class Motor Instruction School, *Rock Island, Ill.*

UNDERHILL, C. R., captain, radio officer, school for aerial observers, Aviation Section, Signal R. C., Langley Field, *Hampton, Va.*

VAIL, E. L., lieutenant, Aviation Section, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned as officer in charge of instruments and accessories.

VERITY, CALVIN W., captain, superintendent of forge shop, Ordnance R. C., Frankfort Arsenal, *Philadelphia.*

WADSWORTH, GEORGE R., major, chief engineer, Naval Aircraft Factory, Navy Yard, *Philadelphia.*

VINCENT, JESSE G., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Miami Hotel, *Dayton, Ohio.*

VONACHEN, F. J., lieutenant, Ordnance Department, U. S. N. A., Rock Island Arsenal, *Rock Island, Ill.*

WALDON, SIDNEY D., colonel, Equipment Division, Signal Corps, U. S. A., *Washington.*

WALL, WILLIAM GUY, major, Ordnance Department, U. S. A., *Washington.*

WALTER, MAURICE, first lieutenant, Ordnance R. C., *Washington.*

WALTON, FRANK, acting sergeant, Quartermaster Corps, U. S. A., Quartermaster Repair Unit, (mail) *Washington, D. C.*

WALTON, HAROLD E., 84th Aero Squadron, Signal Corps., U. S. A., Kelly Field, *San Antonio, Texas.*

WATSON, C. ROY, lieutenant, Aviation Section, Signal R. C., U. S. A., *Washington.*

WEAVER, E. W., aeronautical engineer, Engineering Department, Naval Aircraft Factory, Navy Yard, *Philadelphia.*

WEEKS, PAUL, captain, Ordnance Department, U. S. A., *Washington.*

WEISS, ERWIN A., sergeant, Ordnance Department, U. S. A., *Washington*, assigned to Engineering Bureau, Motor Section.

WELSH, W. E., Signal Corps, Aviation Section, U. S. A., *Washington.*

WETHERELL, S. P. JR., major, Quartermaster R. C., Motor Transport Service, A. E. F., *France.*

WHITTENBERGER, OWEN M., first lieutenant, Ordnance R. C., *Washington*, assigned to Office of Chief of Ordnance.

WILSON, H. C., major, 58th U. S. Artillery, Coast Artillery Corps, *Ft. Schuyler, N. Y.*

WILSON, T. S., lieutenant colonel, Field Artillery, *Santa Fe, N. M.*

WODEHOUSE, B. A., sergeant, Co. A, 339th Infantry, *Camp Custer, Mich.*

WOLFF, RUDOLPH D., U. S. N. R. F. No. 5, Great Lakes, U. S. A., assigned as chief petty officer.

WOOD, C. G., first lieutenant, Quartermaster Corps, U. S. A., *Washington*, assigned to Motor Transport Section, Office of Quartermaster general.

WOOD, FRANK B., captain, technical expert, Air Division, Signal R. C., U. S. A., *Washington*, (mail) 3rd Motor Mechanics Regiment, Camp Greene, *Charlotte, N. C.*

WOOD, HAROLD F., lieutenant, Specification Section, Equipment Division, Signal R. C., *Washington.*

WOODS, S. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

WORKMAN, LEE W., 670th Aero Squadron, Aviation Branch, *Morrison, Va.*

YONKIN, HARRY F., first lieutenant, Ordnance R. C., care Chief Ordnance Officer, A. P. O. No. 717, A. E. F., *France, via New York.*

CIVILIAN SERVICE

ADAMS, PORTER H., Office of the Section Commander, First Naval District, *Rockford, Me.*

ADAMS, RALPH L., Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Section, Motors Division.

ADAMS, H. J., War Industries Board, *Washington.*

AGINS, HERMAN J., draftsman, Quartermaster Corps, U. S. A., *Washington*, assigned to Motor Transport Division.

ANDERSON, E. S., mechanical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, N. Island, *San Diego, Cal.*

ANDERTON, H. C., aeronautical mechanical engineer, Production Engineering Department, Equipment Division, Signal Corps, U. S. A., Lindsey Building, *Dayton, Ohio.*

BARE, ERWIN L., automobile body designer, Office of Quartermaster General, *Washington.*

BARNABY, RALPH S., airplane inspector, Naval Reserve Flying Corps, *Buffalo, N. Y.*

BARNHARDT, GEO. E., aeronautical mechanical engineer, Signal Corps., U. S. A., Wilbur Wright Field, *Dayton, Ohio*, (mail) Cottage B6, Unit No. 1, Signal Corps, Aviation School, *Fairfield, Ohio.*

BARTON, CHAS. E., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned to Airplane Eng. Department.

BELLING, G. C. C., assistant inspector of engineering material, U. S. NAVY, *Buffalo, N. Y.*, (mail) Curtiss Aeroplane & Motor Corp.

BLAKEMORE, THOMAS L., aeronautical engineer, Bureau of Construction & Repair, U. S. N., *Washington.*

BOOTH, FRED C., draftsman, Motor Transport Division, Quartermaster Department, U. S. A., *Washington*, (mail) Room 205, Union Station.

BOURQUIN, J. F., supervisor of chassis assembly, Military Truck Production Section, Office of Quartermaster General, *Washington.*

BRADFIELD, E. S., Engineering Department, Naval Factory, *Philadelphia*

BREWER, ROBERT W. A., inspector of mechanical transports, British Army, London, Eng., (mail) Holt Mfg. Co., *Stockton, Cal.*

BUBNA, RICHARD C., designer, Engineering Office, Motor Transport Division, Quartermaster Corps, U. S. A., (mail) Room 305, Union Station, *Washington.*

BURTON, W. DEAN, aeronautical mechanical engineer, Signal Corps, U. S. A., *Fort Omaha, Neb.*

CALDWELL, FRANK W., aeronautical engineer, Aviation Section, Signal Corps, U. S. A., (mail) McCook Field, *Dayton, Ohio.*

CHAPMAN, ROBERT H., U. S. N., *Spartanburg, S. C.*, assigned to Aeronautical Division.

CHAUVEAU, ROGER, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*

CHERRY, RALPH E., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned to Airplane Engineering Department.

CLARK, ELMER J., Signal Corps, U. S. A., *Portland, Ore.*, assigned as district manager of inspection.

CLARKE, THOMAS A., Signal Corps, U. S. A., *Washington*, assigned to Aviation Section as production expert.

CLEAVER, B. J., Medical Corps, U. S. A., General Motors Truck Plant, *Pontiac, Mich.*

COSTELLO, JOHN V., aeronautical engineer, airplane engineering division, Signal Corps, *Dayton, Ohio.*

COWAN, STUART, special work, Clothing and Equipment Division, Manufacturing Branch, Office of Quartermaster General, 109 East Sixteenth Street, *New York.*

CORLETT, ROBERT C., student engineer of tests, U. S. Army Training School, Carnegie Institute of Technology, *Pittsburgh.*

CREAGER, F. L., in charge of electrical equipment tests, engineering laboratory, Motor Transportation Section, Quartermaster Corps, U. S. N. A., (mail) Room 205, Union Station, *Washington.*

CROW, HAROLD I., School of Military Aeronautics, University of California, *Berkeley, Cal.*, assigned as instructor in aeronautic engines.

DAVIS, CHARLES ETHAN, consulting engineer, Ordnance Department, *Washington.*

DEKLYN, JOHN H., technical assistant, National Advisory Committee on Aeronautics, *Washington.*

DENKINGER, GEORGE MARSHALL, Signal Corps, U. S. A., *Washington*, assigned to Aviation Section as aeronautical engineer.

DICK, ROBERT I., motor truck expert, Ordnance Department, *Camp Dodge, Iowa.*

DIFFIN, F. G., chairman, International Aircraft Standards Board, *Washington.*

DRESSER, L. W., mechanical engineer, Motor Transportation Division, Engineering Section, Quartermaster Corps, U. S. A., (mail) Room 306, Union Station, *Washington.*

DUVAL, EUGENE C., Signal Corps, U. S. A., assigned to Airplane Engineering Department, Mutual Home Bldg., *Dayton, Ohio.*

EDGERTON, A. H., Signal Corps, U. S. A., 870 Woodward Ave., *Detroit*, assigned to Equipment Division as gage supervisor.

EDMONDSON, D. E., U. S. Signal Service at Large, *Washington*, assigned as inspector of airplanes and airplane engines, Ericsson Mfg. Co., *Buffalo.*

EISELE, WILLIAM S., draftsman, Aviation Section, Signal Corps, U. S. A., *Washington.*

ELLIOTT, E. M., chief dispatcher, Emergency Fleet Corp., *Washington.*

ERICSON, FRIEHOF G., representative of Canada, International Aircraft Standards Board, *Washington.*

FERRY, PHILLIPS B., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

FLOGAUS, H. A., designer and checker, Motor Transport Engineering Division, U. S. A., (mail) Office of Quartermaster General, 205 Union Station, *Washington.*

FOWLER, HARLAN D., aeronautical engineer, Production Engineering Division, Aviation Section, Signal Corps, *Washington.*

FRENCH, H. J., senior inspector, Pittsburgh District, Aviation Section, Signal Corps, U. S. A., *Philadelphia*, assigned to Inspection Department.

FROESCH, CHARLES, aeronautical mechanical engineer, Engineering Department, New York Equipment District, Aviation Section, Signal Corps, (mail) Aeronautical Engine Corp., *Long Island City, N. Y.*

FRYER, ROY C., chief instructor, starting, lighting and ignition division, War Educational Department, University of Cincinnati, *Cincinnati.*

GIBSON, HUGO, automotive purchasing, British War Mission, *New York.*

GRIMES, C. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned to airplane engineering department.

GORMAN, E. J. B., U. S. Flying Corps, N. R., U. S. N., *Dayton, Ohio*, assigned to inspection of airplane engines, Dayton-Wright Aeroplane Co.

GRIFFITH, LEIGH M., technical expert, National Advisory Committee for Aeronautics, 518 Munsey Bldg., *Washington.*

GUERNSEY, CHAS., chief draftsman, Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Section, Motors Division.

HALE, W. A., aeronautical mechanical engineer, Signal Corps, U. S. A., *Dayton, Ohio.*

HALLETT, GEO. E. A., aeronautical mechanical engineer, Aviation Section, Signal Corps, Arcade Bldg., *Washington.*

HARRIGAN, F. P., aeronautical engineer, Equipment Division, Airplane Engineering Department, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

HART, FRANK S., designer, Engineering Section, Motor Transportation Division, Quartermaster Corps, U. S. A., *Washington.*

HECKEL, C. E., truck designer, Transport Division, Quartermaster Corps, U. S. A., *Washington.*

HICKS, H. A., aeronautical engineer, Equipment Section, Aviation Section, Signal Corps, U. S. A. (mail) Major E. J. Hall, Lindsey Building, *Dayton, Ohio.*

HOBBS, J. W., automobile expert, Ordnance Department, Rock Island Arsenal, *Rock Island, Ill.*

HOLDEN, F. M., airplane engineering division, Signal Corps, U. S. A., *Washington.*

HONIGMAN, JOS. K., instructor, U. S. School of Military Aeronautics, Princeton University, *Princeton, N. J.*

HOWER, HENRY M., production manager, New London Naval Base, *New London, Conn.*

KINGSBURY, J. A., metallurgist, Aviation Section, Signal Corps, U. S. A., (mail) Trego Motors Corp., *New Haven, Conn.*

KISHLINE, FLOYD F., laboratory assistant, Quartermaster Corps, *Washington.*

KROEGER, F. C., Quartermaster Corps, U. S. A., *Washington*, assigned as engineer on electrical equipment.

KUEMPEL, REUBEN, U. S. N., Naval Air Station, *Pensacola, Fla.*, assigned to Bureau of Steam Engineering.

LADDON, I. M., aeronautical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

LANE, ABBOTT A., inspector, Aviation Section, Signal Corps, (mail) Room 52, 870 Woodward Avenue, *Detroit.*

LEAVELL, R. A., Federal Board for Vocational Education, Washington, assigned as associate professor of mechanical engineering in charge of automobile instruction, Camp Joseph E. Johnston, *Jacksonville, Fla.*

LINCOLN, C. W., aeronautical engineer, airplane engine department, Equipment Division, Signal Corps, U. S. A., *Washington.*

LONGLETZ, WESLEY, Signal Corps, U. S. A., assigned as inspector on airplane engines at The Nordyke & Marmon Co., *Indianapolis.*

LOUDON, WARREN P., expert cost accountant, Signal Corps, U. S. A., *New York.*

MACPHERSON, JAMES W., inspector of airplanes and airplane engines, Signal Service at Large, Signal Service, U. S. A., *Washington.*

MACDONALD, K. B., consulting engineer, Naval Aircraft Factory, *League Island, Philadelphia.*

MCDONALD, E. G., aeronautical engineer, Airplane Engine Division, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

MCCAIN, GEO. L., Signal Corps, U. S. A., *Dayton, Ohio*, assigned to airplane engineering department, Engine Design Section.

MCMASTER, MARCENUS D., aeronautical engineer, Motor Transportation Department, Signal Corps, *Washington.*

MENNEN, F. E., Quartermaster Corps, U. S. A., *Washington*, assigned to Transportation Division.

MILLAR, THOMAS H., JR., Engineering Section, Motors Division, Quartermaster Corps, *Washington*, (mail) Office of Quartermaster General.

MILLER, C. S., automotive engineer, U. S. A., Washington; (mail) 1750 Elkin Ave., *New Albany, Ind.*

MOORHOUSE, A., Signal Corps, U. S. A., Lindsey Bldg., *Dayton, Ohio*, assigned as engineer in Airplane Eng. Dept.

MORGAN, G. W., supervisor of plant survey, Military Truck Production Section, Office of Quartermaster General, *Washington.*

NELSON, A. L., aeronautical engineer, Airplane Engineering Department, Aviation Section, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

NEUMANN, JOHN W., Planning Section, Machine Division, U. S. Navy Yard, *Philadelphia.*

O'MALLEY, JOHN M., aeronautical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, *San Diego, Cal.*

OTIS, J. HAWLEY, Ordnance Department, U. S. A., Camp Dodge, *Des Moines, Iowa.*

PARISH, W. F., Signal Corps, U. S. A., *Washington*, assigned to Specification Section, Equipment Division.

PARKER, VICTOR C., Signal Corps, U. S. A., *Washington*, assigned to Equipment Division.

PARRIS, JR., EDWARD L., senior inspector, Aviation Section, Signal Corps, (mail) Ericsson Mfg. Co., *Buffalo.*

PERRIN, J. G., aeronautical mechanical engineer, Production Engineering Department, Signal Service at Large, care Major B. D. Gray, *Washington.*

POLLOCK, RAY C., Signal Corps, U. S. A., *Buffalo*, assigned as airplane engine inspector.

PROCTOR, C. D., Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section, Carriage Division.

RANDALL, J. M., assistant inspector of ordnance, Ordnance Department, U. S. A., (mail) Nash Motors Co., *Kenosha, Wis.*

RICE, HARVEY M., inspector, Signal Service at Large, Signal Corps, (mail) Willys-Overland Co., *Toledo, Ohio.*

RIDER, W. KEITH, Production Engineering Department, Signal Corps, U. S. A., *Dayton.*

RIPPINGILLE, E. V., Aviation Section, Signal Corps, *Washington.*

ROBERTS, D. S., inspector of airplanes and airplane engines, Aviation Section, Signal Corps, U. S. A., (mail) Standard Aircraft Corp., *Elizabeth, N. J.*

ROBERTS, SAMUEL B., inspector of airplanes and airplane engines, Signal Service at Large, U. S. A., (mail) Sturtevant Aeroplane Co., *Jamaica Plain, Mass.*

RUCKSTELL, G. E., Signal Corps, U. S. A., assigned as aeronautical mechanical engineer, *Detroit.*

RUSSELL, L. L., Engineering Office, Motors Division, U. S. A., (mail) Office of Quartermaster General, 305 Union Station, *Washington.*

RYMARCZICK, GUSTAV M., Signal Corps, U. S. A., (mail) Splitdorf Electrical Co., *Newark, N. J.*, assigned to Aviation Sect., as senior inspector, Signal Service at Large.

SALISBURY, EDWARD V., chief of motor transportation, American International Corp., Government Shipbuilding Yard, Hog Island, *Philadelphia.*

SHAW, B. RUSSELL, Aviation Engineering Department, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

SCHELL, JOHN A., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

SEABURY, W. M., Field Hospital, No. 337, Camp Custer, *Battle Creek, Mich.*

Applications *for* Membership

The applications for membership received between June 17 and July 2, 1918, are given below. The members of the Society are urged to send any pertinent information with regard to these names which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ALBRIGHT, EDWARD C., draftsman, Lexington Motor Co., *Connersville, Ind.*

BAIR, C. L., stockholder in company and engineer, Auto Specialties Mfg. Co., *St. Joseph, Mich.*

BATTEN, PERCY H., works manager, Wallis Tractor Co., *Racine, Wis.*

BROWN, FRED. I., general superintendent, Alamo Farm Light Co., *Hillsdale, Mich.*

CAMPBELL, W. R., head of tools, Machine Shop, Premier Motor Corp., *Indianapolis.*

COLLINS, W. D., chief draftsman, Stutz Motor Car Co. of America, *Indianapolis.*

CRITTENDEN, CLIFFORD L., checker, Militor Corp., *Jersey City, N. J.*

DAVIS, MAYNARD N., experimental engineer, Cleveland Tractor Co., *Cleveland.*

FABER, CHAS. J., designer, airplane engineering department, Bureau of Aircraft Production, McCook Field, *Dayton, Ohio.*

FINE, LEWIS, chief engineer, Budd Wheel Corp., *Philadelphia.*

FROST, FRANK R., asst. to general manager of sales, Superior Steel Corp., *Pittsburgh.*

GATELY, EDWARD A., department head, The Simms Magneto Co., *East Orange, N. J.*

GOODWIN, J. K., secretary, treasurer, Jackes-Evans Mfg. Co., *St. Louis.*

HAMILTON, DOUGLAS T., advertising manager, The Fellows Gear Shaper Co., *Springfield, Vt.*

HANSON, HENRY L., draftsman, Aeromarine Plane & Motor Co., *Keyport, N. J.*

HARKNESS, JOHN L., engineer of tests, L. W. F. Engineering Co., *College Point, N. Y.*

HOOPER, J. CHARLES, Cincinnati Ball Crank Co., *Cincinnati.*

KARNS, WM. C., manager, co-partner, A. M. Karns & Sons, *Everett, Pa.*

LEHR, A. A., purchasing agent, engineer, Wilson Co., *Detroit.*

MCCASH, PERRY V., superintendent, U. S. Mail Truck Service Station, Wiles & Foy, *Seattle, Wash.*

MCMILLAN, HORATIO G., vice-president, general manager, The Industrial Equipment Co., *Oakland, Calif.*

MARSH, E. S., aeronautical mechanical engineer, Bureau of Aircraft Prod., Production Engineering Dept., *Washington.*

MERRITT, RALPH N. S., asst. in experimental laboratory, Nordyke & Marmon Co., *Indianapolis.*

MURRAY, J. R., secretary, treasurer, production manager, J. W. Murray Mfg. Co., *Detroit.*

MUSSELMAN, C. A., treasurer and general manager, The Chilton Company, *Philadelphia.*

NORTON, FREDERICK H., aeronautical engineer, Signal Corps, Massachusetts Institute of Technology, *Cambridge, Mass.*

OSWALD, HARRY ALVIN, night general superintendent, Naval Aircraft Factory, Navy Yard, *Philadelphia.*

[illegible] manager, Interior Metal Mfg. Co., *Jamestown, N. Y.*; president, engineer of illumination, Omolite Co. Inc., *Jamestown, N. Y.*; president, general manager, Steel White Co. Inc., *Jamestown, N. Y.*

PUFF, MICHAEL J., draftsman, Airplane Engineering Department, Signal Corps, McCook Field, *Dayton, Ohio.*

SEIDELL, L. R., chief metallurgist, Wright Martin Aircraft Corp., *New Brunswick, N. J.*

STEELE, ELIJAH JAMES, special automobile equipment salesman, Waltham Watch Co., *Waltham, Mass.*

TEETOR, CHAS. N., superintendent, Teetor-Hartley Motor Corp, *Hagerstown, Ind.*

VERNOR, JAMES C., president and general manager, Texas Motor Car Assn., *Fort Worth, Texas.*

WALKER, HIRAM L., asst. chief engineer, Chandler Motor Car Co., *Cleveland.*

WELLS, HAGVEY J., factory manager, chief engineer, Texas Motor Car Assn., *Fort Worth, Texas.*

WILLIAMS, ALFRED O., general manager, South Bend Gear Co., *South Bend, Ind.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between June 17 and June 24, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

BROWN, WILLIAM (J) Aircraft Division, Research Department, Bureau of Construction & Repair, Navy Department, *Washington*, (mail) 1351 Harvard St.

BLAKELY, E. M. (M) mechanical engineer, Sears, Roebuck & Co., Dept. 47, *Chicago.*

DE LA GARDE, LOUIS A. C. (A) lieutenant, first class engineer, workshops officer, Motor Transport, Army Service Corps, Chiswick, London, England, (mail) Eynsham, 38 Sutton Court Road, *Chiswick, London, England.*

DUCORRON, C. A. F. (M) senior inspector, Signal Corps, U. S. A., c/o Nordyke & Marmon Co., *Indianapolis.*

HELLMANN, LUI F. (M) civil and mechanical engineer, (mail) 1549 Leonard St., *Indianapolis.*

HENZIE, FRANK D. (A) Reed & Glaser, 1602-3 Merchants Bank Bldg., *Indianapolis.*

REES, JOHN H. (M) general manager, Hawkee & Co., Kapunda, South Australia, (mail) c/o Clyde Cars Co., *Clyde, Ohio.*

Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described briefly as soon as possible after their receipt, the purpose being to show concisely the general nature of their contents and to give an estimate of their value.

THE LAW OF AUTOMOBILES. By Xenophon P. Huddy, LL.B. Fourth Edition, by Howard C. Joyce. Published 1916, by Matthew Bender & Company, Inc., Albany, N. Y. Buckram, 6 by 9½ in., 608 pages. Price $5.50.

As the manufacture and employment of automobiles has progressed at a rapid pace in recent years, the development of automobile law has likewise expanded so that any uptodate book attempting to record even the noteworthy laws and judicial decisions in this field must be of considerable size.

As stated by the author, the book is compiled for the use of the layman, lawyer, and judge. Its purpose is to present all the legal information on the subject that exists, including the reported judicial decisions in America and England, which have decided questions pertaining to the automobile and its operation.

The work also treats of those principles and rules of law closely allied to the operation of automobiles which concern subjects other than the self-propelled vehicle, such, for example, as the law of the road as applied to vehicles generally.

An accurate compilation of all the state automobile laws in the United States and also the English Motor Car Act are to be found in the book.

In the preface to the second edition, which was published early in 1909, the author stated that in addition to making the book valuable as a textbook, he wished to make it interesting reading. So far as a book on law may be interesting to a layman, the author has succeeded in his purpose, and even touches of humor are found throughout the book. For instance, as an illustration of the totally changed attitude of the public and courts toward the automobile, between the present time and less than a decade ago, he quotes the Court of Appeals of Georgia, in deciding that the automobile is not dangerous *per se*, as follows:

"It is insisted in the argument that automobiles are to be classed with ferocious animals, and that the law relating to the duty of the owners of such animals is to be applied. It is not the ferocity of automobiles that is to be feared, but the ferocity of those who drive them. Until human agency intervenes, they are usually harmless.

"While by reason of the rate of pay allotted to the judges in this State, few, if any, have ever owned one of these machines, yet some of them have occasionally ridden in them, thereby acquiring some knowledge of them; and we have, therefore, found out that there are times when these machines not only lack ferocity, but assume such an indisposition to go, that it taxes the limits of human ingenuity to make them move at all. They are not to be classed with bad dogs, vicious bulls, evil-disposed mules and the like."

In making the above quotations, the author champions the case of the automobile in the following words: "The Court of Appeals of Georgia, speaking through Mr. Justice Powell, is both right and wrong in the above assertions. That the automobile is not dangerous *per se* is correct, but the intimation that the modern motor vehicle is not a success as a road vehicle is erroneous, since the automobile has already proved to be a practical vehicle. The incorrect statement was not made seriously."

In the preface to the present—the fourth—edition the author states that since the publication of the previous edition the field has so broadened as to require the inclusion of considerable new matter. This is illustrated by the recent introduction of the automobile for the general carriage of passengers and in some cases of freight, vehicles thus used being popularly designated as jitneys. A chapter has been added covering this subject, showing their position as carriers and rules and principles which are controlling of their operation, both in respect to other carriers and to the public in general.

Another matter which it has been deemed advisable to treat in a separate chapter, is that of insurance, in its relation not only to automobiles as subjects of insurance but in respect to the liability of such companies for injuries of a physical nature or for death caused in their operation.

The work aims to cover the entire subject of automobile law, treating among other matters such questions as the duties and liabilities of chauffeurs, unauthorized use of machines, hiring of automobiles, violations of traffic in statutory regulations, the manufacture of automobiles, licensing and registration, collisions in crossing railroad tracks. Pedestrians and other users of the highway are continually attracting the attention of the courts in order to determine questions of right or liability arising out of the reciprocal rights and duties involved. In the chapters relating to these matters there is a complete presentation of law as it stands today.

Eighty odd pages in the back of the volume are devoted to a table of the cases cited, arranged alphabetically with reference to the section numbers throughout the book, and a general reference index which is a good aid in tracing decisions on specific subjects.

The following general subjects are covered by the book: Definitions and general considerations; historical; nature and status of the automobile; right of automobiles to use highways and streets; registration and licensing; operation on highway in general; rights, duties and liabilities of automobile drivers; meeting and passing; overtaking and passing; turning corners; frightening horses; duty to stop automobile; pedestrians and miscellaneous; proof of speed; unlawful speedings on the public highways; dangerous automobile driving; defending speed cases; the garage and garage keeper; the hire of automobiles; the chauffeur; chauffeur's authority to bind his employer; the manufacturer of automobiles; taxicab and public automobile service; sales of automobiles; warranties and representations; safety of roads for automobiles; automobile legislation; federal control over motoring; insurance; jitneys.

Concluded on page 52, Advertising Section